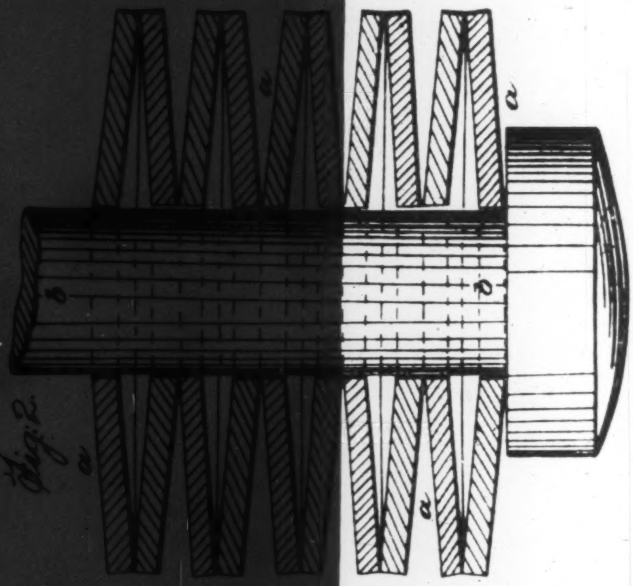
SEPTEMBER 4, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY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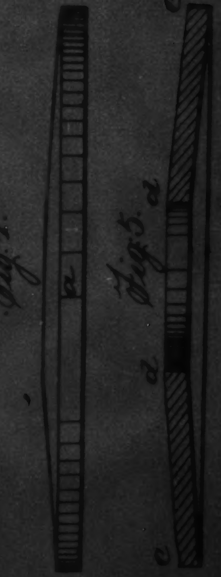
Fig. 4.
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Fig. 5.
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Conical-Disc Springs

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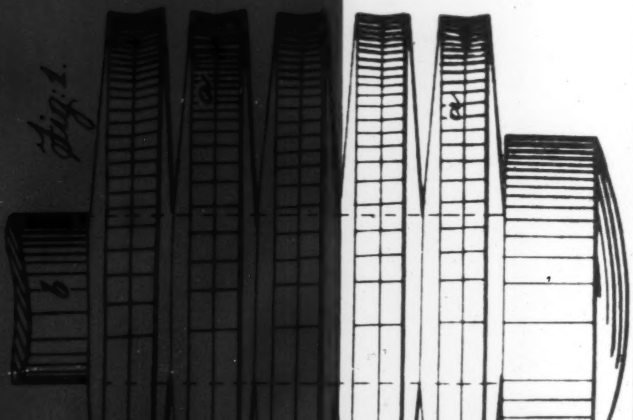
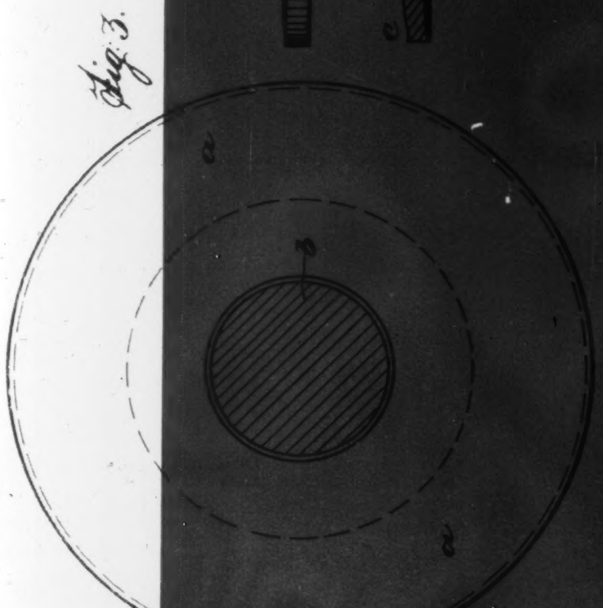


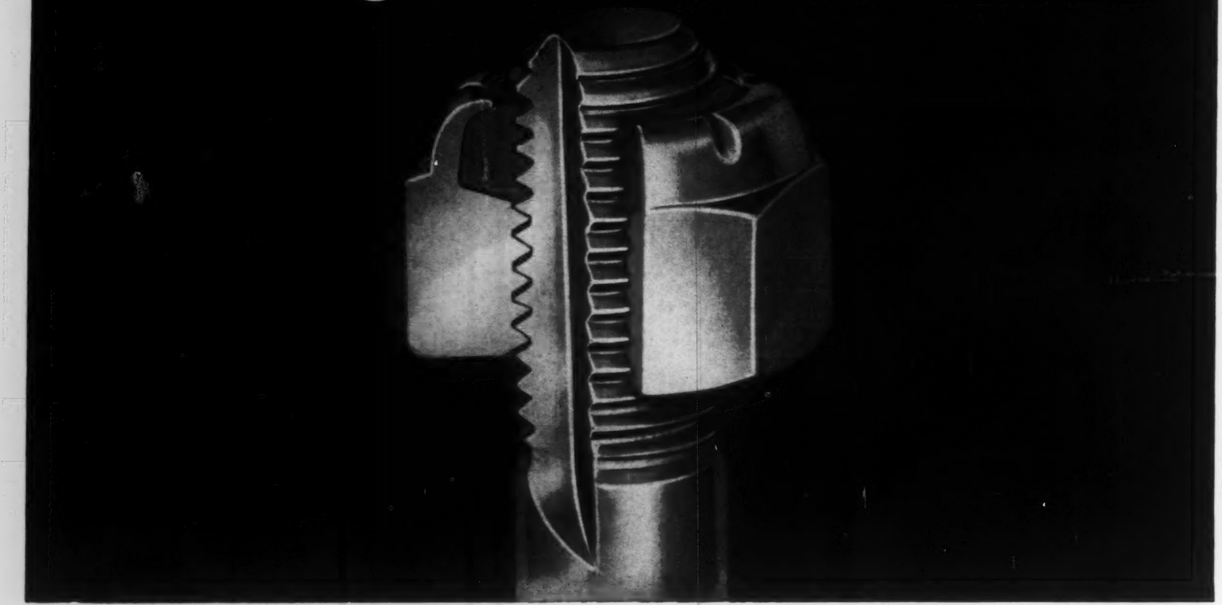


INVENTOR.

J. F. Belleville
by A. Pollok
his atty

FARNSWORTH

The nylon collared Elastic Stop® nut never damages bolt threads!



The nylon locking insert* will not seize threads, gall or remove plating

The red nylon locking collar is an integral part of an Elastic Stop nut. Undersize in diameter in relation to standard bolt tolerances, this insert grips the entering bolt threads with strong, smooth nylon fingers that dampen impact loads and resist turning under the most severe conditions of vibration or shock. The perfect fit between bolt threads and the locking collar also serves to seal off internal bolt and nut threads and to protect them against corrosion. Furthermore the nylon insert is impervious to gasolines, oils, salt atmospheres, cleaning compounds and common acids. The remarkable wear resistance of nylon plus its elastic recovery makes Elastic Stop nuts reusable through more than a hundred on and off cycles.

Because an Elastic Stop nut is a one-piece unit it is less expensive to install than castellated nuts and cotter pins, or double nuts. Equally important, it is a *stop* nut that *locks at any position on the bolt* without requiring secondary "safety" devices; it is simple to adjust precisely—it is easily wrenched off or readjusted. Elastic Stop nuts have been used by American industry since 1930 to solve the toughest applications on railroad, automotive, earth moving and farm equipment, as well as on all types of electrical machinery.

Elastic Stop nuts are available in sizes ranging from a watchmaker's 0-80 through 3", and in many standard finishes and materials including carbon and stainless steels, brass, duronze and aluminum.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA

also maker of the ROLLPIN TRADEMARK

*The Red Locking Collar is a Registered Trademark of ESNA

Elastic Stop Nut Corporation of America
Dept. N27-94, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name__________ Title__________

Company__________

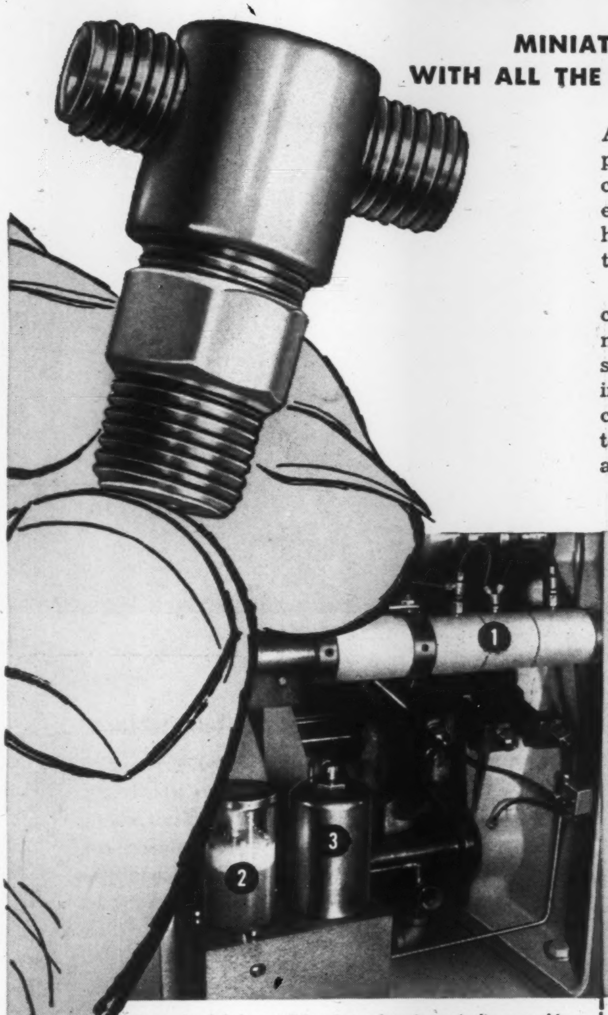
Street__________

City__________ Zone____ State__________

Circle 401 on Page 19

NOW! Any Machine Can Have The Advantages of Centralized Lubrication...At Low Cost!

Alemite "MINIATURE" ACCUMITE System



MINIATURE SIZE FOR LIMITED SPACE—WITH ALL THE QUALITY OF HIGHER-PRICED SYSTEMS!

Alemite—with 40 years of centralized lubrication experience—announces an all-new miniature system complete with pump, metering valves and controls—especially designed to service many machines and vehicles where centralized lubrication has been impractical until now!

Alemite's new midget-size Accumite system is especially adaptable to light, precision, multiple-bearing machines that have limited installation space. Its small size and simple installation overcomes cost limitations in most plants. Typical applications are: packaging, canning, labeling and textile machines . . . and machine tools. It is also suitable for tractor trailers, lift trucks and farm implements.

ACCURATELY METERS THESE SHOTS OF OIL OR GREASE

.003 cu. in. .006 cu. in. .009 cu. in.

ALL THE ADVANTAGES OF "BUILT-IN" MEASURED LUBRICATION—PLUS MIDGET SIZE!

- Meters exact amounts of refinery-clean lubricants to all bearings whenever system is operated.
- Eliminates shutdown time for lubrication.
- Seals lubricant against dirt, grit and water.
- Prevents bearing troubles due to neglect or use of wrong lubricants.
- Services all bearings in one operation.
- Avoids work spoilage and bearing repairs due to over-lubrication.

Accumite lubricates 24 points of spring winding machine. 1. Valves mounted directly on bearings. 2. Transparent lubricant reservoir. 3. Manually controlled air pump, actuated by "push-pull" valve.

ALEMITE
DIVISION
STEWART-WARNER
CORPORATION

Symbol of
SW
Excellence

1850 Diversey Parkway, Chicago 14, Ill.

Mail coupon for full information!

ALEMITE, Dept. BB-98
1850 Diversey Parkway, Chicago 14, Ill.

Please send me all the facts about your new "Miniature" Accumite system.

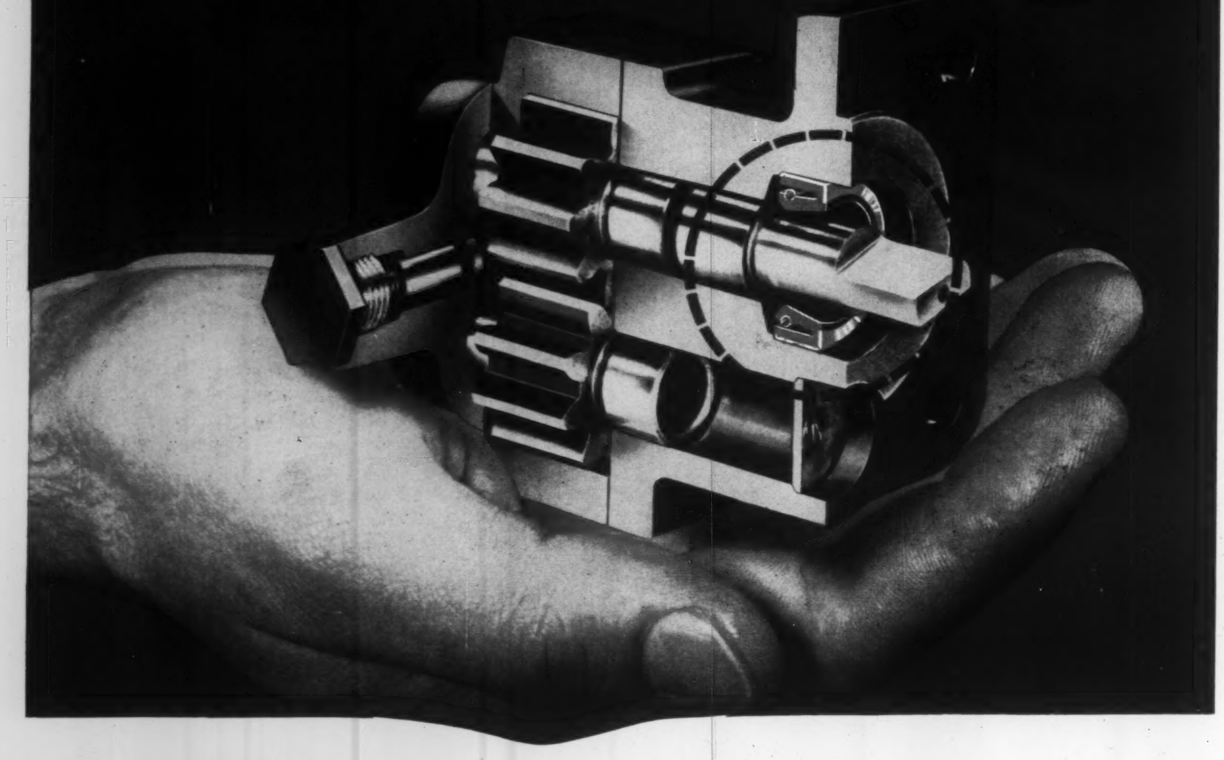
Name____________________

Company____________________

Address____________________

City__________ Zone____ State__________

Champion performance in a fist-sized pump...sealed by C/R



THE PROBLEM:

To seal a rotary pump handling a wide range of fluid viscosities, pressures and temperatures

These pumps are performing dependably in hundreds of different hydraulic applications. They handle any fluid with lubricating qualities . . . deliver up to 180 gph, and maintain high volumetric efficiency even with low viscosity fluids. This particular pump also carries Underwriters' Laboratories approval for use in oil burners. For dependable sealing, C/R's Type HMS Oil Seal was chosen. It performs effectively from 28″ Hg to 5 psi, and from 50 to 8000 rpm. This is only one of the thousands of ways in which C/R Oil Seals and engineering are solving difficult sealing problems throughout industry. C/R engineers can help you, too—especially where critical conditions exist. A letter or telephone call will get them started for you. Write for your copy of the catalog, "C/R OIL SEALS."

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

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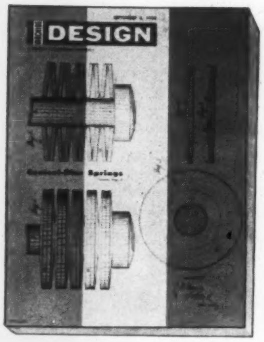
Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario. **Export Sales:** Geon International Corp., Great Neck, New York
C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

OIL SEAL C/R DIVISION

CHICAGO RAWHIDE



Front Cover: The original U. S. patent issued to Julien F. Belleville of France is superimposed on the French national colors by artist George Farnsworth. Belleville's invention of a new spring form was the forerunner of present-day conical-disc springs. The latter-day versions are discussed in the article by Earl Fortini on Page 139.

September 4, 1958

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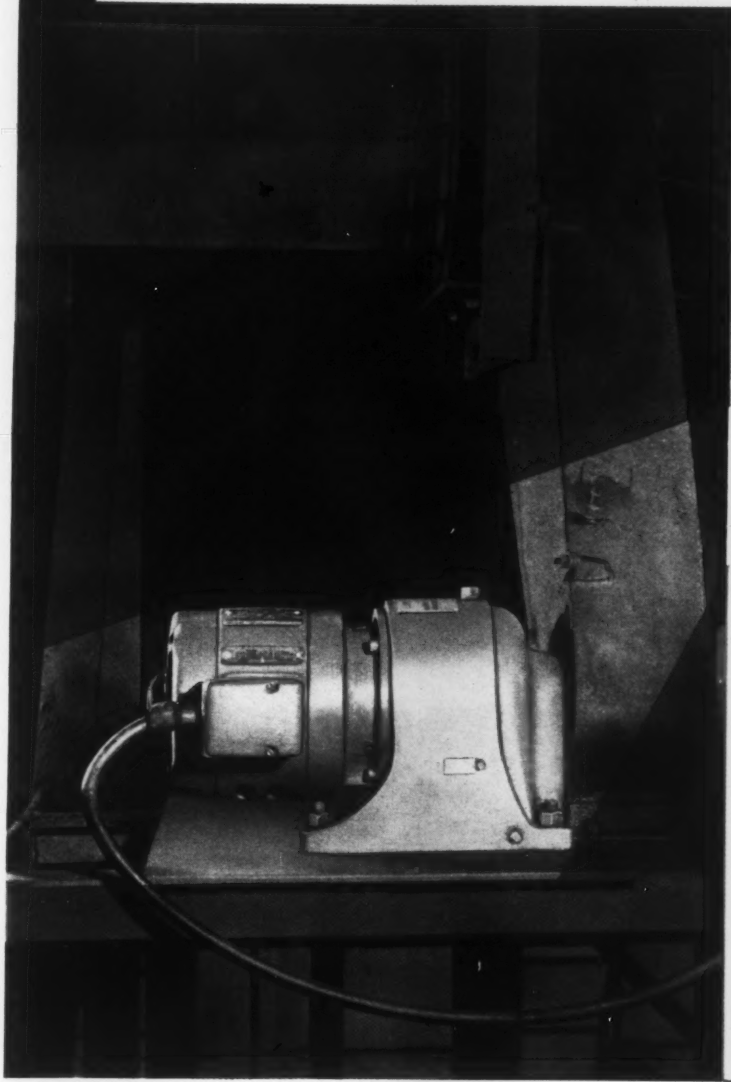
Tight space? Perfect place for a Link-Belt Gearmotor



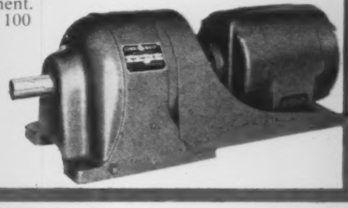
Maintains life-long alignment with flange-mounted NEMA motors

Here's a speed reducer right in step with industry's campaign for higher productivity in less space. Because its gear trains incorporate a minimum of parts . . . because its motor is directly connected to the gear drive with a flange—the Link-Belt Gearmotor is the ultimate in compactness.

Imagine how these same features cut costs. The flange connection eliminates additional coupling devices. Simple gear trains have fewer parts to wear, to service, to invite trouble.

You'll find them in Book 2447. Call your nearby Link-Belt office.

LINK-BELT MOTOGEAR—for bracket-mounting all makes and enclosures of foot-type NEMA motors — simplifies motor replacement. Sizes to 100 hp.



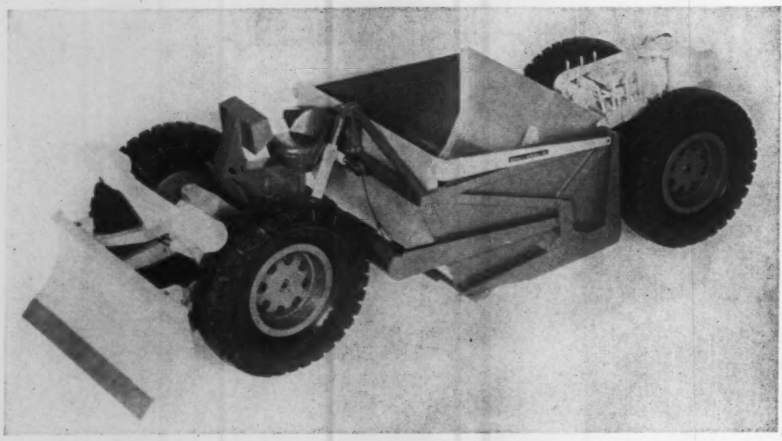
LINK-BELT

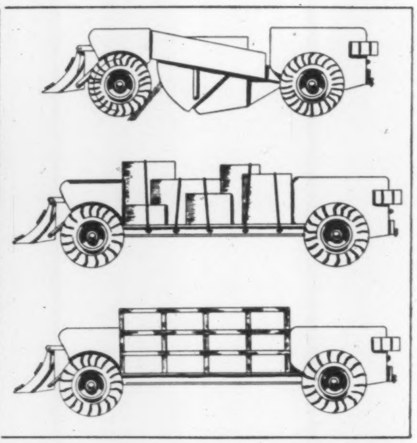
SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,806-A

MACHINE DESIGN

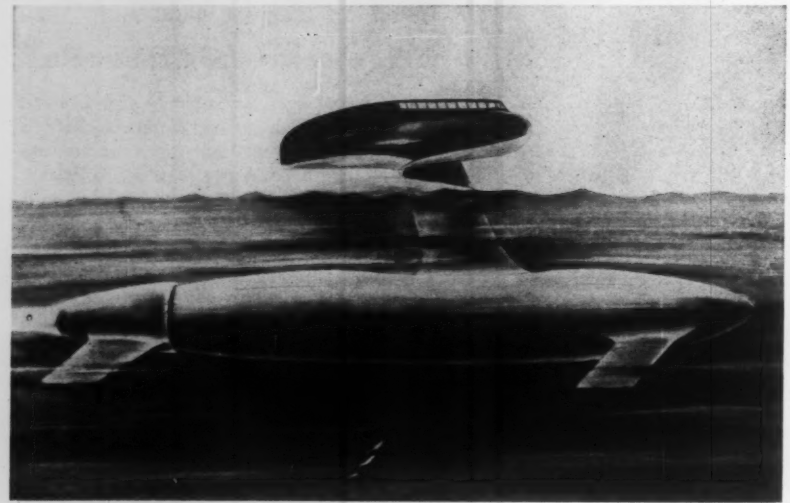
ENGINEERING NEWS





U. S. Army Photograph

DETACHABLE FRONT AND REAR SECTIONS permit insertion of a variety of center-body configurations in this new airborne tractor being developed for Army Engineers. The unusual vehicle features a rear mechanical drive system which generates electric power for the front drive system. When ballasted (with dirt), the machine is capable of dozing and prime moving at twice the work potential of conventional earthmovers of comparable size. It can substitute for a dump truck without the need for crane-shovel or loader equipment. Designated Bat, for ballastable, all-purpose tractor, the machine is being made by Barnes-Reinecke Inc., Chicago.



MORE SPEED ON LESS POWER is the goal of a concentrated research program on underwater cargo vessels. A simple principle is involved: Submerged hulls don't generate waves, thus have much less drag than surface vehicles. This jet-propelled model, conceived by Aerojet-General Corp. for the U. S. Maritime Commission, is controlled from a gondola atop a 100-ft tall strut. Air for the powerplant is drawn through the strut, snorkel-fashion. Underway, the ship is operated with excess positive buoyancy. A triaxial control system provides steering control, longitudinal and transverse stabilization, and hydrodynamic control required to force the ship to its proper operating depth. In effect, the craft flies underwater. The ultimate source for driving the jet-propulsion pumps is a nuclear powerplant.

Cool Jewel Outshines Tube and Transistor

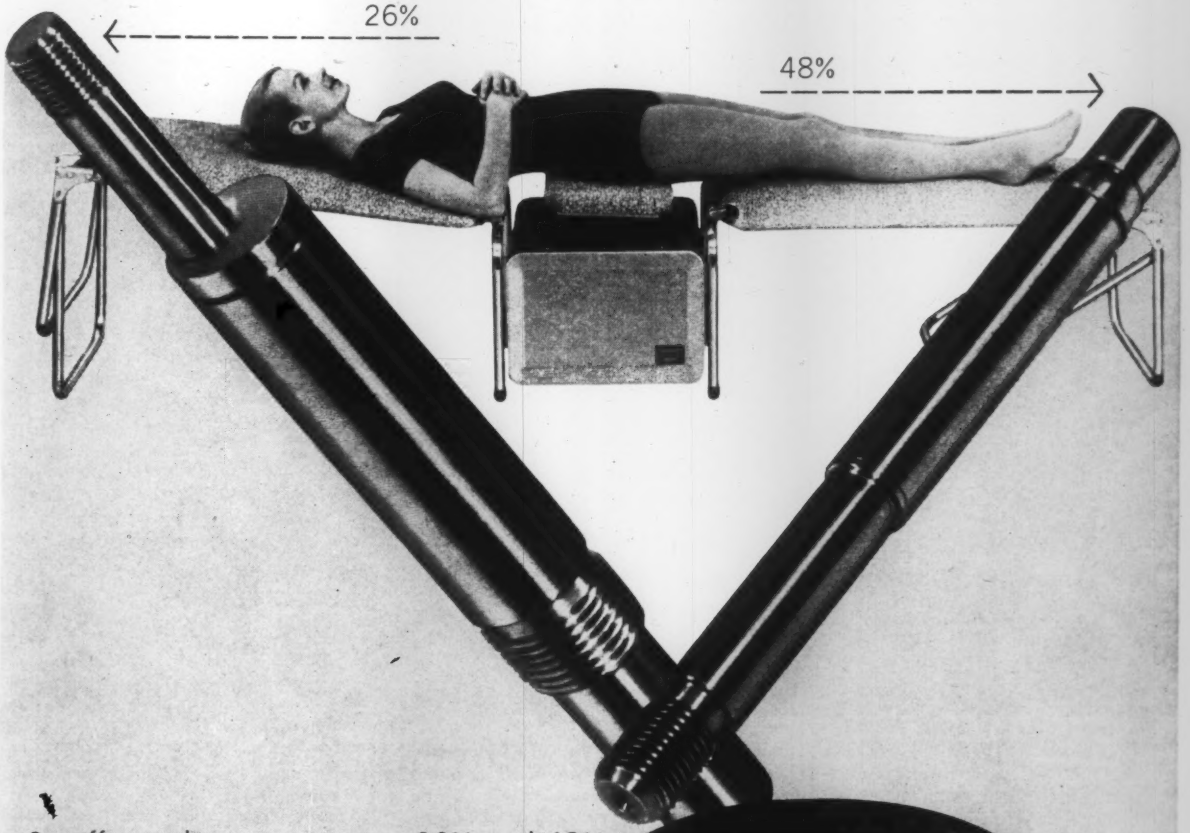
Man-Made Rubies Amplify Extremely Weak Radio Signals

ANN ARBOR, MICH.—Synthetic rubies, held at temperatures near absolute zero, promise great improvements in communication in the microwave frequency range of 1000 to 20,000 megacycles. The rubies are part of a new amplifier developed at the University of Michigan and called a ruby maser. Applications of the maser would mean television transmission over much longer distances than presently possible, communication from space vehicles, and improved military surveillance equipment.

At the high operating temperatures of ordinary vacuum tubes and even during room-temperature operation of transistors, atomic motion produces radio noise. In the ruby maser, the ruby is placed in a magnetic field and immersed in liquid helium, which slows atomic motion and drastically reduces

SHE is improving her figure on a Stauffer "Magic Couch." And although she doesn't know it, Stauffer makes two of the Magic Couch's most important operating parts from La Salle ground and polished STRESSPROOF® steel bars. This means that her Magic Couch will last longer, will be more dependable.

Stauffer reduces cost figures, too!



Stauffer reduces part costs 26% and 48% by using ground and polished *La Salle* **STRESSPROOF®** STEEL BARS WITH COPPER

ELIMINATES Heat Treating

This eccentric shaft . . . and this idler shaft, two of the most important parts of Stauffer's Magic Couch, were formerly made of heat treated C-1137. But Stauffer design engineers recommended a change to La Salle ground and polished STRESSPROOF® steel bars . . . with copper.

The result: no need for rough grinding . . . no need for heat treating. Production costs were reduced 26% on the eccentric shaft . . . 48% on the idler shaft.

La Salle ground and polished STRESSPROOF® can help *your* per-part cost. It gives high strength without heat treating . . . it machines 50% to 100% faster than heat treated alloys . . . it minimizes warpage . . . it makes a better part at a lower cost.

To find out how STRESSPROOF® can help you, just write for a copy of Helpful Data Bulletin No. 15, "Improve quality . . . cut costs" . . . or for production applications ask for a sample bar for test purposes.

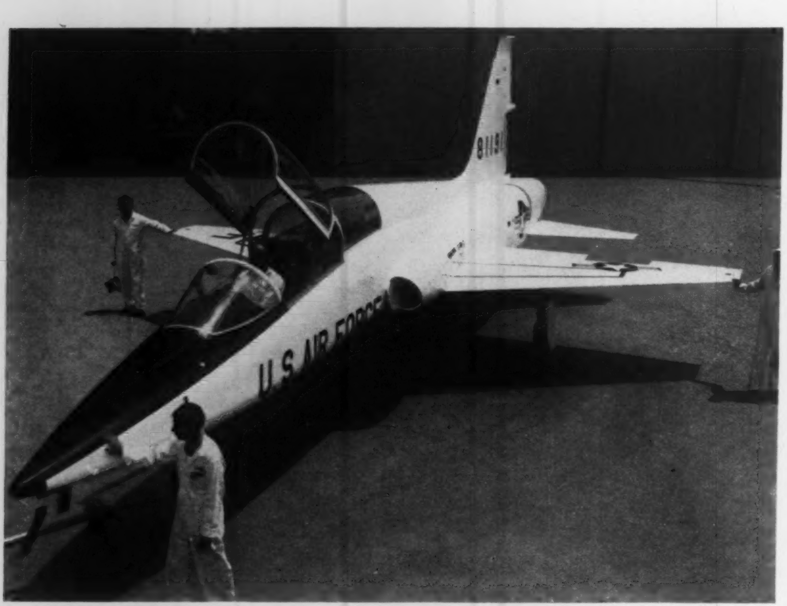
La Salle STEEL COMPANY
1426 150th Street, Hammond, Indiana

Circle 407 on Page 19

noise. The magnetic field aligns the electrons of the ruby's atoms. Electrical energy supplied to the electrons is released by an incoming radio signal, producing a large signal output.

Sensitivity of the maser is such that it can detect the tiny natural radio emission from any object warmer than the ruby itself. It can detect radiation from cool bodies a short distance away or from invisible stars which may be thousands of light years distant.

A ruby maser will be incorporated in a new 85-ft radio telescope under construction by the University at Peach Mountain, near Dexter, Mich.



HIGH THRUST-TO-WEIGHT RATIO is an outstanding feature of Northrop Aircraft's T-38, twinjet trainer. It weighs one-half to two-thirds as much as operational fighters, has a top speed of around 850 mph. Twin-engine reliability is a strong safety factor in the new craft. In the event of engine failure during takeoff, the plane can complete its takeoff on one engine. T-38 will be the first step in supersonic flight for the coming generation of pilots who will fly chemically-fueled bombers, Mach-3 fighters, and boost glide vehicles. Instructor and student are seated tandem in individually pressurized cockpits enclosed by separate jettisonable canopies. A fixed, clear plastic panel installed between cockpits provides windblast protection for the instructor if bailout is necessary.

Gold-Glass Sandwich Makes Fog-Proof Windshield

BIRMINGHAM, ENGLAND—Defrosters with fans and blowers are outdated by an aircraft-type windshield adapted to automotive use.

Originally developed for military airplanes by Triplex Safety Glass Co., Ltd., the new windshields have a transparent film of gold and metal oxide 0.0000002 in. thick inserted on the inner face of one sheet of the laminated glass. The film operates on 24 to 240 v, and will carry 1000 w per sq ft if necessary. Thickness of the windshield does not exceed 5/16 in., and curved glass panels up to 30 x 42 in. are being produced. The heated glass assures positive de-misting and de-icing.

Another application of glass-heating uses resistance wires less than 0.001 in. in diameter which are practically invisible. Installation and operation are similar to the gold-film method.

In both systems, a thermostat cuts off electric power when temperature of the glass reaches about 40 C.

Topics

Sports cars a la mode: A group of air-conditioned Hillman Minx economy cars was offered for sale in the South and Southwest. Priced at $1699 plus $375 for the air conditioner, the 200 cars sold "immediately," according to their British manufacturer.

• • •

Down on the farm, U. S. leads Russia in mechanization. Two members of a Dept. of Agriculture observer group, who inspected farms in the Soviet Union, reported that Russian farm machinery is about 25 years behind that of the U. S. They added, however, that the gap appears to be closing rapidly.

• • •

Delivery of concrete by air was the unusual assignment of a helicopter in the construction of power lines across a mountain range. The plane first brought crews to the construction sites, and while they prepared holes for footings, it went back after containers of wet concrete. The helicopter hovered while the mix was poured directly into the holes.

• • •

His master's loud voice: RCA engineers have built a device capable of producing a noise of 160 db, which is 10,000 times as noisy as heavy street traffic. Purpose of this acoustic giant is testing sensitive electronic equipment designed for use in jet planes, missiles, and rockets. The noise is created by forcing compressed air through two pyramid-shaped horns into a plywood box measuring 5 x 5¾ x 6 2/3 ft.

• • •

Clear reflection of the dentist's operating field is provided by a new mirror whose surface, revolving at approximately 21,000 rpm, utilizes centrifugal force to maintain an image free of dental debris. Only slightly larger than a conventional dental mirror, the Roto-Mirra has a tiny turbine driven by compressed air delivered through a plastic hose into the mirror handle. The mirror is a product of Super-Dontic Mfg. Co. Inc., Atlanta.

• • •

Wave meter, for measuring the waviness of the sea, was developed to provide data on the force that water exerts against various types of piling at various depths. Such information is necessary to engineers designing docks or off-shore oil drilling equipment. The meter is a movable section in the middle of piling set vertically in the water and attached to a pier. Strain gages register distortion of bars which hold the movable section and thus measure the force of the waves.

The Panelbuilder

66 YEARS OF SERVICE
CUTLER-HAMMER
CONTROL
C-H

News for and about Panelbuilders

Cutler-Hammer Inc., Milwaukee, Wis. *Division:* **Airborne Instruments Laboratory.** *Foreign:* **Cutler-Hammer International, C. A.**
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.

TO SET— DEPRESS BRONZE POINTER
SECONDS
CUTLER-HAMMER

SYNCHRONOUS TIMERS PROVIDE GREATER ACCURACY, FLEXIBILITY, DEPENDABILITY

Recently, Cutler-Hammer announced a new line of synchronous motor driven control timers. Available in one, three, and five minute models, the new timers are ideally suited for all industrial control systems requiring a precise, easily adjustable, dependable timing relay.

Timer Dial Reads Directly in Seconds

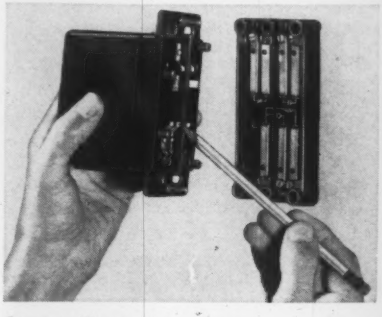
One of the many plus features of these Cutler-Hammer Synchronous Control Timers is the timer dial which is calibrated directly in seconds. No longer is it necessary to guess at setting the timing interval. Just rotate the bronze pointer to the dial position corresponding to the exact interval desired . . . no approximations or tedious readjustments necessary. And of course, the direct reading timer dial serves as a lasting reminder as to the time setting without having to check its timing interval with a stop watch.

The sweep second pointer provides a visual count down when in operation . . . a valuable feature when setting up closely sequenced machine operations.

Automatic Operation— Greater Repeat Accuracy

The operation of these new timers is completely automatic. After each timing cycle the sweep second pointer returns to the start position. Also, the pointer will return to the start position if a power interruption occurs while the timer is in operation, thus eliminating the possibility of an undertimed cycle.

The Cutler-Hammer Synchronous Timer is ruggedly built, requiring virtually no maintenance. The timers are not adversely affected by dust or climatic changes and maintain the highest degree of repeat accuracy.

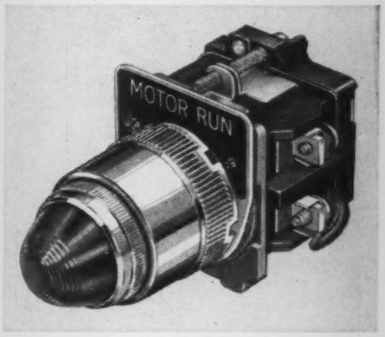


The one minute timer is adjustable in one second increments from 0 to 60 seconds, the three minute timer in 3 second increments—0 to 180 seconds, and the five minute timer in 5 second intervals—0 to 300 seconds. All three models are dimensionally identical and easily interchangeable without disturbing the mounting base or wiring. The timing unit is removed from the mounting base during installation for maximum wiring freedom.

For further information, see your nearby Authorized Cutler-Hammer Distributor or write for Publication EN-33- S243.

CUTLER-HAMMER Inc., Milwaukee 1, Wisconsin.

PRESTEST® INDICATING LIGHTS CHECK OWN BULB CONDITION



Indicating lights are vital to the safety and proper use of many machines, particularly in automation. But such lights always pose a troublesome question. When an indicating light is "off", is it indicating the true circuit condition or is the bulb burned out? There is no guesswork with the Cutler-Hammer PresTest Indicating Light. Merely pressing on the PresTest lens disconnects the lamp from its operating circuit and checks it instantly on a continuously energized test circuit. So simple and easy, it ends the hazards of infrequent testing. Cutler-Hammer PresTest Oil Tight Indicating Lights are amazingly compact. The resistor type requires only $1\frac{7}{8}''$ back-of-the-panel space, and the transformer type requires only $1\frac{23}{32}''$. The wide angle visibility lenses come in six different colors. For full information on PresTest and other matching heavy duty oil tight pushbutton units, write today on your company letterhead for the Master Design, Publication EL-178- S243.

Circle 408 on Page 19

Proton Serves as Probe in Magnetic Field Measurement

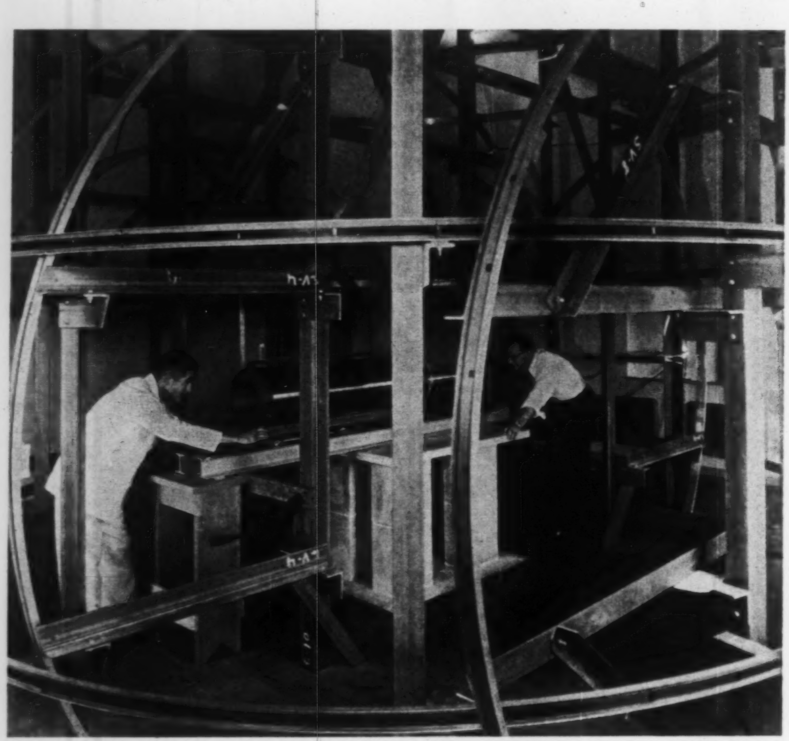
NBS Finds New Value For Hydrogen Nucleus Constant

WASHINGTON—Designers of industrial and scientific apparatus have available a new and better standard for magnetic-field measurement. Making use of the proton (hydrogen-atom nucleus) as a sensitive, minute probe, the technique permits precise measurement of field strength and distribution in electromagnets, servomechanisms, and other industrial and laboratory equipment.

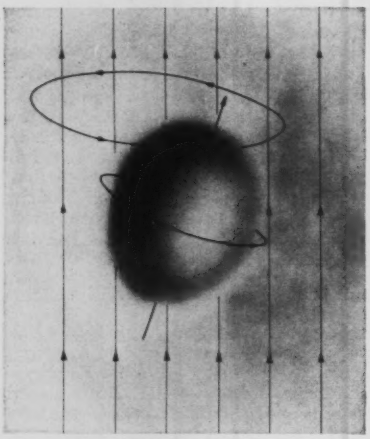
Accuracy of the method depends upon exact knowledge of a fundamental physical constant—the gyromagnetic ratio of the proton. Last week, the National Bureau of Standards announced that it had redetermined this important constant. The new value: (2.67513 ± 0.00002) x 10^4 rad/sec/gauss.

Like other atomic nuclei, the proton behaves like a small magnet. When placed in a magnetic field, it tends to orient its axis along the direction of the field. However, the proton is also spinning rapidly about its axis, and the resulting angular momentum causes it to act like a gyroscope. Thus, instead of lining up with the field, the proton actually precesses about the field direction. The ratio of angular precession frequency to magnetic field strength gives the proton gyromagnetic ratio.

In reporting the new value for the ratio, the Bureau pointed out that the redetermination makes possible more accurate values for many of the fundamental constants of physics whose values depend upon magnetic field measurements. Examples are the electron charge-to-mass ratio, and Plancks constant.



Giant apparatus is used to measure the gyromagnetic ratio of the tiny proton. Magnetic field generated by solenoid (center) causes protons in a water sample to precess at an accurately measurable frequency. Large coils surrounding the apparatus compensate for the earth's magnetic field.



Proton precesses in a magnetic field. The applied field (vertical arrows) produces a torque on the proton which causes it to precess through the horizontal circle shown. It acts like a small spinning magnet with a magnetic moment as indicated by the straight arrow through its center.

Soviets Study Satellite Tumble To Solve Re-entry Problems

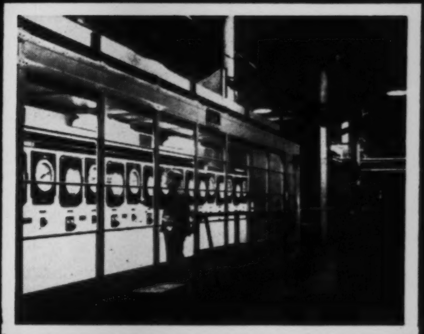
WASHINGTON—Soviet scientists are giving first priority to a study of the laws by which a satellite tumbles while orbiting. In the case of Sputnik III, this somersaulting motion has been the subject of more than 38,000 radio measurements and 1200 optical observations. The satellite rotates around a cross-sectional axis once every 40 sec.

Purpose of the Soviet study is directly concerned with returning a satellite to the earth. First attempts may be to return just the satellite's instruments. These would be housed in a separate container and powered by a small rocket engine. At precisely the right moment, the container must be separated from the satellite and its motor automatically started. Orbiting speed will thus be cancelled.

However, to cancel the velocity it is necessary to direct the braking rocket exactly counter to the motion of the satellite, and its flight must be carefully oriented so that it does not inherit the satellite tumbling action.

So far, the scientists have solved only one part of the problem: Why the satellite somersaults. The action is caused by irregular combustion of the last-stage rocket's fuel at the instant of pushing the satellite into orbit.

ARISTOLOY



No guesswork here. Soaking cycles and temperatures are accurately recorded from this room. Each pit is individually controlled, and soaking of different steels can be varied to meet your requirements.

CONTROLLED SOAKING Produces Controlled Quality Steels

Controlled heating before rolling aids in producing controlled quality steels. Copperweld's new battery of soaking pits provides precise regulation of temperature and time during this important operation. The benefit to customers — controlled quality and improved Aristoloy products.

ARISTOLOY
STEELS

COMPLETE INFORMATION
about Aristoloy electric furnace carbon, alloy, and stainless products, available as blooms, billets, and bars.

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Aristoloy Steel Division
4017 Mahoning Avenue • Warren, Ohio
EXPORT: Copperweld Steel International Co. • 225 Broadway, New York 7, N. Y.

AMERICAN STEEL
WAREHOUSE ASS'N

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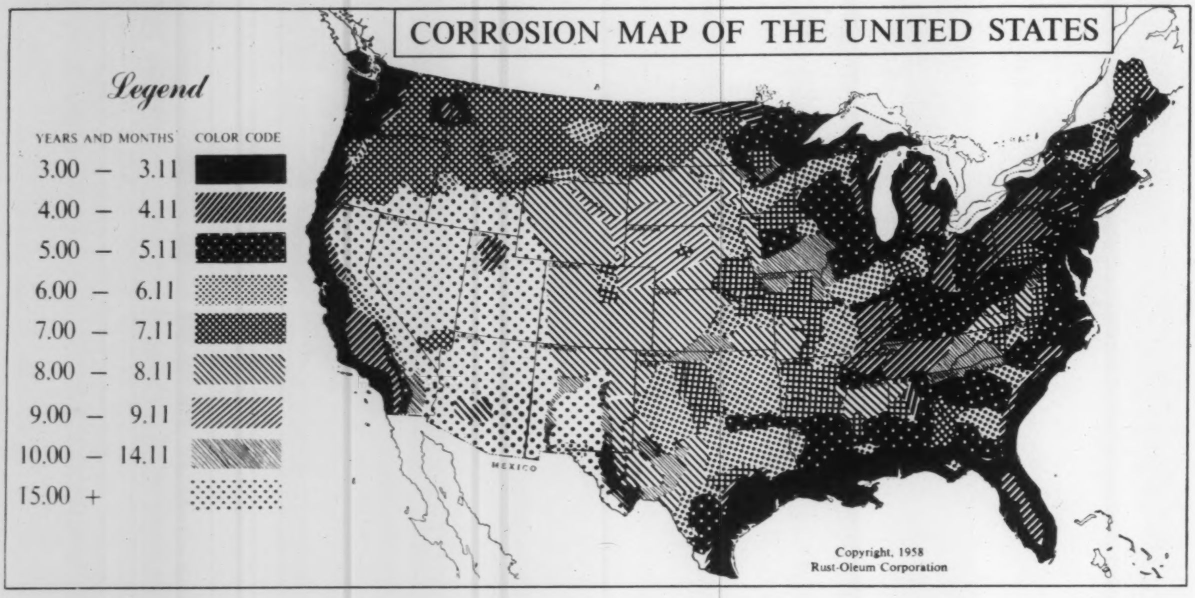
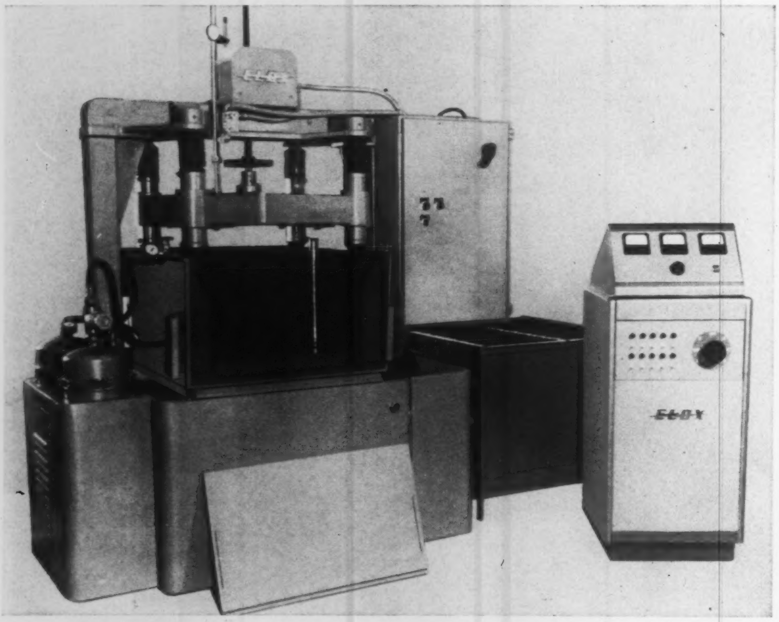


RUST PRODUCTION in the U.S. is proceeding at maximum capacity, according to an unusual and extensive index compiled recently by Rust-Oleum Corp., Evanston, Ill. During a 25-yr research program conducted by the company, thousands of dated and uncoated test panels of 28-gage, low-carbon, cold-rolled sheet steel were left exposed to the elements at industrial sites throughout the country. All cities of more than 10,000 population were included. Fastest rust rate in the country—3 yr—occurs in Buffalo, Rochester, Erie, and Miami. Slowest rate — more than 15 yr — is in Tuscon and Santa Fe. In all major industrial areas, the rate is under 4 yr. Rust rate was described as the time required for the test panel to lose all structural integrity. In most cases, panels were rusted through in at least one place. Rust bill this year: $7½ billion.



FAST METAL-REMOVAL RATES in electrochemical machining are possible with this 500 to 50,000-amp unit developed by Elox Corp., Royal Oak, Mich. Operating at 5000 amp, with an electrode area of 100 sq in., the big machine will remove 30 cu in. of metal per hr. At 50,000 amp, and with an electrode area of 1000 sq in., it will remove 300 cu in. per hr. In operation, electrode and workpiece are submerged in a saline solution. A servo-feed system automatically advances the electrode into the workpiece.

Portable Silencers To Quiet Navy Jets

BALTIMORE, MD.—Portable jet-engine silencers at various Naval airfields throughout the country will protect maintenance personnel and nearby residents from excessive jet noise during flight-line engine run-up. The silencers will quiet the most powerful jet engines in production, including the J-57, J-65, J-71, and the J-79. The Metal Products Div. of Koppers Co. Inc., Baltimore, Md., has contracted to furnish 30 silencers, the first to be delivered in six months.

According to the company, the silencer can be adapted for use with any type of jet aircraft, commercial or military. There is no attachment to the aircraft itself; the silencer is simply rolled into position behind the engine.

Company engineers say that the unit is the first completely portable silencer to be successfully tested behind a jet aircraft. Several of the design features used were developed by the Martin Co. and are em-

10A — B — C
TORRINGTON STAINLESS STEEL AIRCRAFT BEARINGS

When Airspeed Makes the Weather Horizontal...

When the weather comes in at hundreds of miles per hour, no seal can keep rain out of exposed anti-friction bearings.

For such applications, Torrington Aircraft Needle Bearings and Cam Followers are made available in stainless steel. This material resists corrosion pitting and prevents the formation of areas of increased stress in bearing contact surfaces. Life expectancy is greatly increased for exposed airframe applications.

These advantages of stainless steel, coupled with the high inherent capacity provided by the full complement of rollers, make Torrington Aircraft Type Needle Bearings ideal where space and weight are at a premium. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TYPE RT—high strength stud with rollers and outer race designed to roll on a hardened steel track.

TYPE NBC—inner race, outer race, rollers and washers securely fastened to inner race.

TYPE NBK—inner race, rollers and self-aligning spherical OD outer race mounted in spherical ID ring.

TYPE NBF—extra heavy outer race for heavy rolling loads. Also available in double row NBL series.

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

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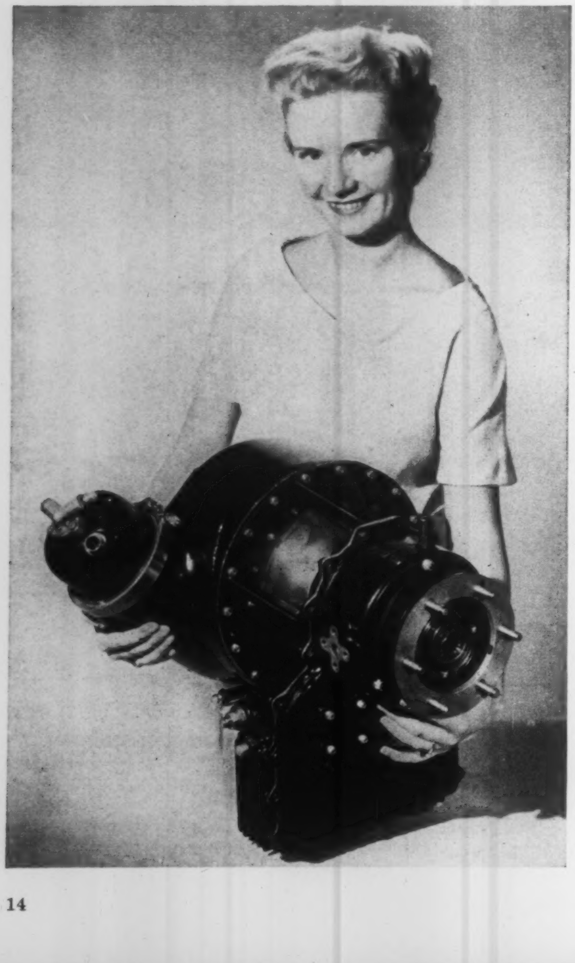
ployed under license agreement with them.

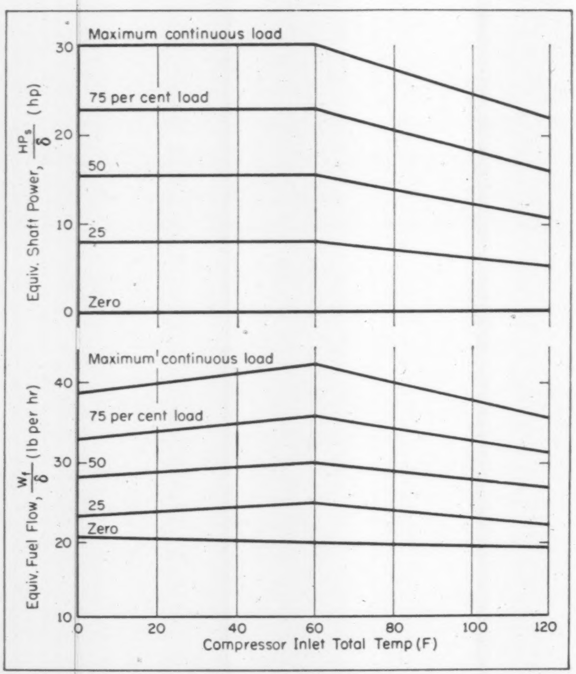
Tests have shown the silencer reduces jet noise by as much as 30 db, equivalent to a 90 per cent reduction of the impact on the eardrum. This is enough to prevent hearing damage to operating personnel and to protect close neighbors of Naval installations from jet noise.

Glass-coated, ceramic capacitors, developed by Gulton Industries Inc., Metuchen, N. J., will operate continuously at temperatures ranging from −60 to 225 C. Previous high-temperature limit for capacitors was 150 C, according to Gulton.

The new units, called Glennite Hi-T, have successfully passed 1000-hr tests at 225 C, at twice their rated voltage. Subminiature in design, they have an insulation resistance of 10,000 megohms at 25 C, 100 v dc. Leads are pure silver.

25-YEAR FATIGUE LIFE is designed into the structure of Grumman's twin-propjet Gulfstream. Added safety comes from the very low skin stresses in the pressurized compartments of the fuselage, plus a number of other fail-safe features. Gulfstream is the first U. S. propjet aimed exclusively at the executive aircraft market. Two Rolls Royce Dart engines give the new craft a maximum cruising speed of 370 mph at a normal cruise altitude of 25,000 ft. The plane carries from 10 to 19 passengers and can operate from runways under 4000 ft long. Range is 2200 mi. Grumman will begin delivery early in 1959 on a backlog of 27 planes.




Maximum continuous load
75 per cent load
50
25
Zero
Equiv. Shaft Power, $\frac{HP_s}{\delta}$ (hp)
0
10
20
30
Maximum continuous load
75 per cent load
50
25
Zero
Equiv. Fuel Flow, $\frac{W_f}{\delta}$ (lb per hr)
10
20
30
40
0
20
40
60
80
100
120
Compressor Inlet Total Temp (F)

POWER IN A SMALL PACKAGE is provided by this 45-lb, 30-hp gas-turbine power unit designed for a wide variety of drive applications. Developed by AiResearch Mfg. Div., Garrett Corp., the new engine operates from sea level to 20,000 ft. Other specifications:

- Turbine Speed: 53,800 rpm
- Output shaft speed: 8000 rpm
- Overspeed cutout: 56,500 rpm
- Turbine inlet temp: 1460 F
- Fuel: gasoline or kerosine
- Overhaul period: 1000 hr

Science News Challenges Crime, Sports, Comics

Survey Shows Americans Read All About It, Want More

ANN ARBOR, MICH.—News of scientific developments is of high interest to 25 per cent of the adult American population, according to a survey by the University of Michigan. The study of 1919 adults was sponsored by the National Association of Science Writers and New York University with a grant from the Rockefeller Foundation.

Some significant statistics revealed by the survey are:

- One-fourth of the people interviewed read all nonmedical science news items. (One-third read all medical items, which are generally the preference of women, while men prefer nonmedical news.)
- Three-fourths can recall at least one specific science news item.
- Two-thirds would like to see more science news in the papers and wouldn't object to its replacing other news.

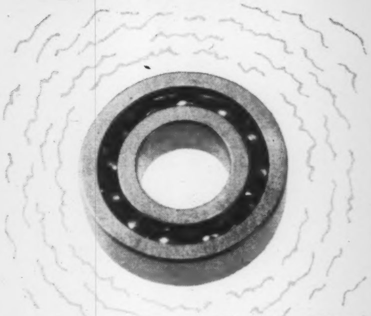
Interviewees' sources of science news are newspapers, mentioned by 67 per cent; television, 41 per cent; magazines, 34 per cent; and radio, 13 per cent. Exposure to these media was: Newspapers, 91 per cent; TV, 86 per cent; radio, 81 per cent; magazines, 66 per cent.

To make room for more newspaper coverage of scientific items, 19 per cent of those interviewed would reduce crime news; 17 per cent, sports news; 13 per cent, advertising; 6 per cent, politics; and 5 per cent, scandals. A dedicated 10 per cent would even give up the comics.

Dr. Robert C. Davis, UM Study Director, describes the "science consumer" as young or middle-aged, generally above average in income and education with a high level of science information, interested in keeping up with the world, curious to learn how science will determine his destiny and his chances for survival; he deems science beneficial and does not blame scientists for possible bad consequences of their discoveries.

Dr. Davis estimates that at the time of the survey newspapers devoted less than 5 per cent of their space to science news. However, the study was made back in 1957.

Operates at 1100° F.!



This 7/8"-OD bearing carries a 150-lb. load with a slow oscillatory motion at temperatures to 1100°F. while subjected to vibration and severe corrosion conditions. Other special high-temperature bearings by ITI meet even tougher requirements.

Used in jet engine components, this special bearing operates at temperatures from 600° to 1100°F. under severe oxidation and corrosion conditions, for a minimum service life of 300 hours. Balls and races are special cobalt-chromium-nickel alloy for hot hardness and durability.

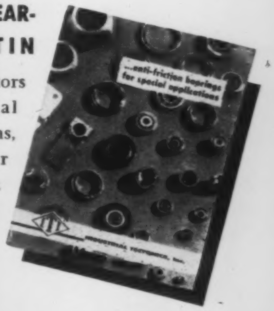
As with all high-temperature bearings, success depends largely on careful attention to internal geometry and other minute detail, based on experience and bearing engineering know-how. At high temperatures, available materials that have the required hardness, wear and corrosion properties are frequently marginal with regard to load-carrying and fatigue characteristics, especially when operating temperatures exceed ceilings of available lubricants.

We have designed and manufactured high-temperature bearings to meet a wide variety of requirements as to speed, load, temperature and service life.

IF YOU need anti-friction bearings of *special shape, size, heat resistance, corrosion resistance, low torque, ultra precision, nonmagnetic properties, or other unusual characteristics,* we can supply them — designed and built to your specific requirements. We invite your inquiries.

NEW 24-PAGE BEARINGS BULLETIN

tells about the factors involved in special bearing applications, and describes our work in this field. *Write for Bulletin AFB-2.*



INDUSTRIAL TECTONICS, Inc.

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3679 JACKSON RD., ANN ARBOR, MICH.

WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

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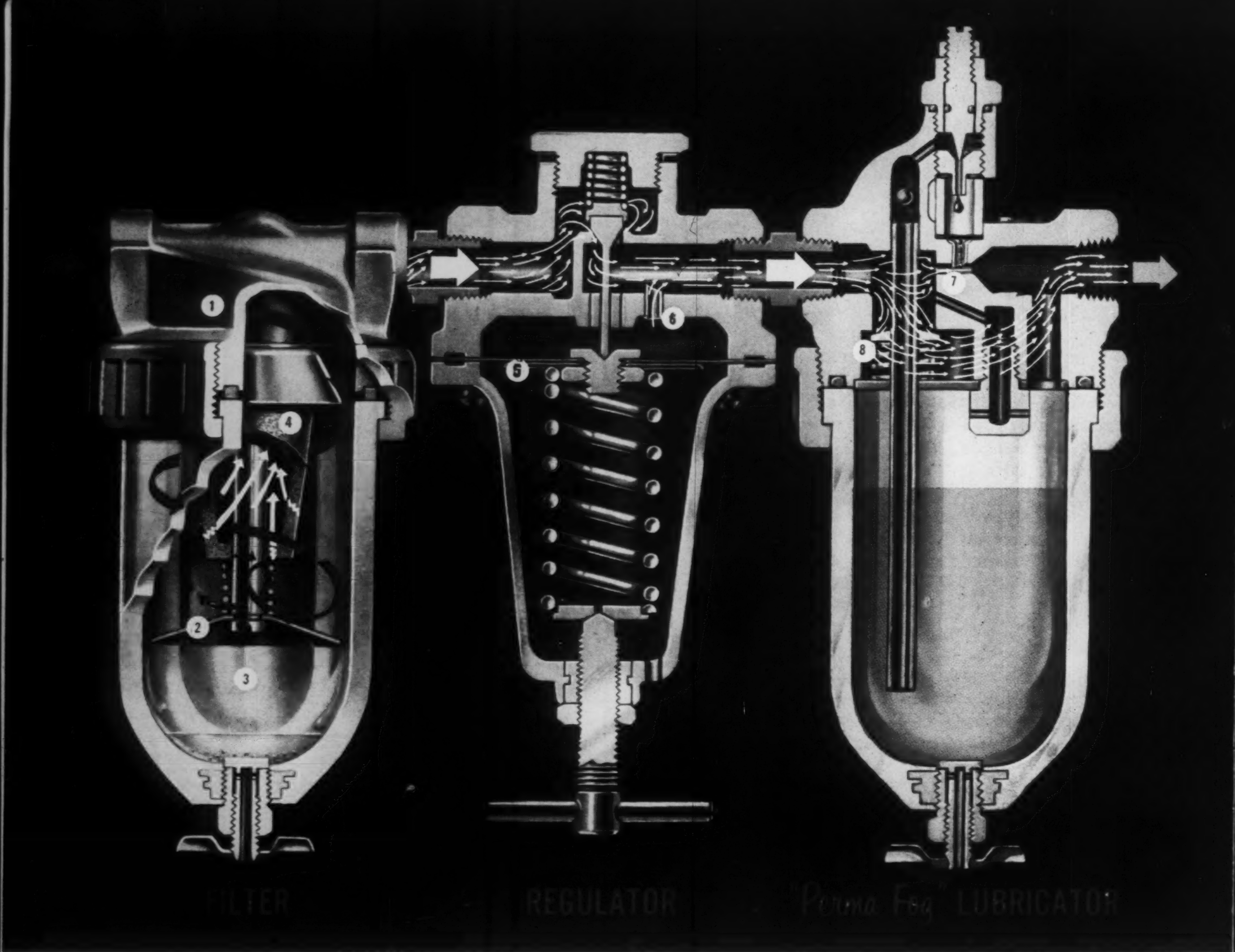

Curved inlet ① directs incoming air in downward helical pattern. Larger impurities and condensate are "thrown out" by centrifugal action, collecting on bowl sides and spiraling downward past baffle ② into quiet chamber for draining off. Baffle traps sediment in quiet chamber ③ and allows only dry air centrifugally cleaned of larger impurities to reach porous bronze filter element ④ where finer particles are filtered out.

Diaphragm of large area ⑤ is of BUNA-N—imparts extra sensitivity for response to even minute reduced pressure variations. Aspirator ⑥ acts directly on diaphragm, providing instant compensation for fluctuating loads . . . assures precise control and stabilizes pressures reaching individual pieces of equipment.

High velocity venturi section ⑦ provides ultra-fine, enduring atomization at air flow rates even less than 1 CFM. An exclusive by-pass feature ⑧ provides lubrication at high flow rate without excessive pressure drop—wide range performance in **one unit.** Proof of lubricating efficiency assured because **all** visible metered oil is atomized.

NOW! Get this efficient TRIPLE LIFE-GUARD protection for your pneumatic equipment

A continuous supply of clean dry air . . . at a constant pressure . . . with just the right amount of lubrication provided at points of friction and wear. Air-operated equipment requires this three-way protection today; the Watts combination of pneumatic controls *assures* it.

You can expect *high efficiency* from the Watts line of advanced-design air line filters, regulators, and "Perma-Fog" lubricators. It's the *quality* assembly. Specialists in protection and control devices since 1875, Watts is setting new *standards* of efficiency in pneumatic operation.

WATTS

FILTERS
REGULATORS
LUBRICATORS

YOUR SAFE PROTECTION

Circle 412 on Page 19

Watts Regulator Company—Industrial Division—8 Embankment Road—Lawrence, Massachusetts

It's a technical bulletin as well as catalog, describing the complete line of Watts Pneumatic Products. Complete engineering and operational data is furnished so that each page is, in fact, a specification sheet. Saves valuable time for the designer.

Reader Information Service

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for More Information . . .

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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SEPT. 4, 1958

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401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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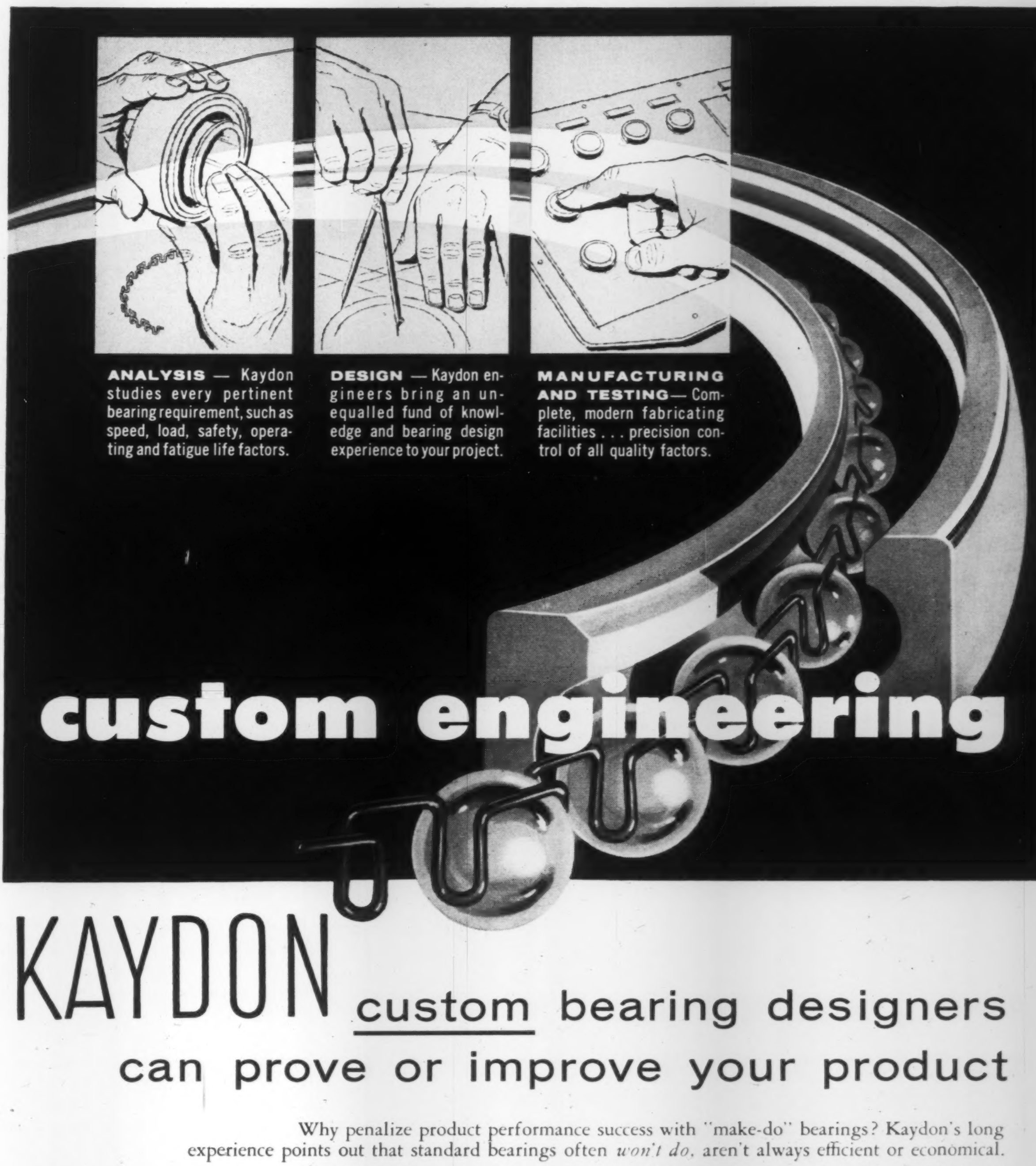


ANALYSIS — Kaydon studies every pertinent bearing requirement, such as speed, load, safety, operating and fatigue life factors.

DESIGN — Kaydon engineers bring an unequalled fund of knowledge and bearing design experience to your project.

MANUFACTURING AND TESTING — Complete, modern fabricating facilities . . . precision control of all quality factors.

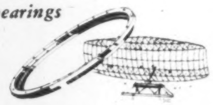
KAYDON custom bearing designers can prove or improve your product

Why penalize product performance success with "make-do" bearings? Kaydon's long experience points out that standard bearings often *won't do*, aren't always efficient or economical.

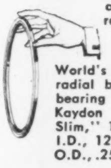
Kaydon engineers creatively design, develop and manufacture special, modified, and standard ball and roller bearings. All-new Kaydon "idea bearings" or modified types will help you *prove* your new product designs; *improve* your redesigns. Kaydon can incorporate millionth's-of-an-inch precision, light weight or super-rugged construction to exactly match the bearing to your application.

Send us sketches or scale prints of your bearing problem. *There's no obligation.*

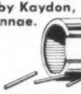
Typical Kaydon-developed special bearings



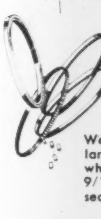
World's largest precision ball bearing (165") designed and built by Kaydon, rotates radar antennae.



World's thinnest radial ball bearing — Kaydon "Reali-Slim," 12.00" I.D., 12.500" O.D., .250" thick.



World's newest Thin-Shell Needle Bearing — for automotive and industrial use.



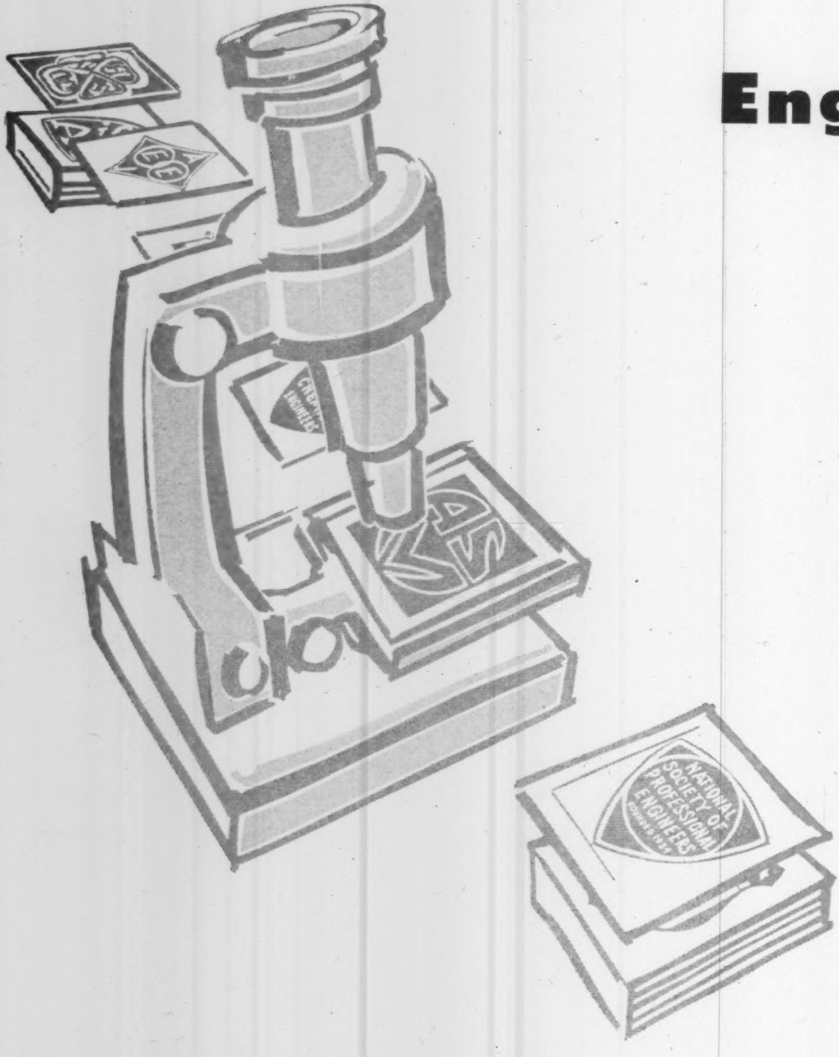
World's lightest large aircraft wheel bearings 9/16" cross section.

THE KAYDON ENGINEERING CORP.
MUSKEGON, MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller *Roller Thrust *Roller Radial *Needle Roller *Ball Radial *Ball Thrust Bearings.

K-581

Circle 413 on Page 19


NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

Engineering

Constantly growing in membership and financial assets, societies serve engineers at local, national, and international levels in technical, educational, and professional matters. Today, however, they are being challenged to provide effective leadership, and many seek adoption of a workable plan for unity.

ENGINEERING societies are booming, pacing the hectic growth of the engineering profession itself. With few exceptions, their coffers are expanding, membership lists are growing, and headaches are multiplying. ASME for the year 1956-57, for example, reported expenses of $2,307,000; SAE, $1,841,000; and ASM, an estimated $2 million.

As revealed by the size of their budgets, some engineering societies are large, complex organizations engaged in a multitude of activities. In technical and certain other activities, they do very well. In effectively promoting professionalism and reaching the interests of individual members, they are not doing as well as many members expect.

Society officers at the national level keep carefully attuned to the situation. They act through committees, conduct surveys, and make progress toward unity — slowly. They try, with varying degrees of success, to reach their members.

Over-all, the activity of technical, educational, and professional engineering societies has reached jumbled proportions. Societies overlap, special-interest groups break away to form splinter organizations, and independent groups merge. Inside each organization, some members demand more specialization, others protest overspecialization and, almost invariably, too many members fail to attend meetings.

But on the positive side, more and more attention is being paid to professional and educational engineering societies and ultimately, to unification of all groups serving the engineer and his profession.

Societies . . . *Big Business*

Founder Societies

Of the more than 100 engineering societies scattered throughout the country, perhaps the best known are the "Founder Societies." These include the American Society of Civil Engineers (ASCE, organized 1852), the American Society of Mechanical Engineers (ASME, 1880), the American Institute of Electrical Engineers (AIEE, 1884), the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME, 1871), and the American Institute of Chemical Engineers (AIChE, 1908).

Representing a combined membership of more than 215,000 engineers, these five societies act jointly in a number of programs, one of which is the erection of a new United Engineering Center in New York, to be completed in 1960. The $10-million, 20-story building will serve as headquarters for the Founder Societies and for eleven associated societies. United Engineering Trustees Inc., an organization set up by the Founder Societies, is in charge of planning and construction of the building.

The Founder Societies also support the Engineering Societies Library, largest nongovernmental collection of technical volumes in the world. The library makes books available to society members throughout the world. More than half of the users make their requests by telephone or mail. Four of the Founder Societies (exception is AIChE) also sponsor a placement service, the Engineering Societies Personnel Service (ESPS), which has offices in New York, Detroit, Chicago, and San Francisco.

Action and reaction

Each society, of course, promotes a multitude of activities for its own members in their areas of engineering interest. Meetings and activities of ASME, as an example, illustrate similar operations of each of the other Founder Societies.

In ASME's last annual report, former president William F. Ryan commented on the society's progress in technology:

> The statistics on number of meetings held, their attendance, the number of papers presented and pages published, our activities in research and in preparation of Codes and Standards are solid evidence of the technological health of the Society and its service to the membership and to the national economy.

However, in the same report, he observed a significant number of delinquencies in dues and resignations:

> Obviously the Society has failed to meet the expectations of a large number, in some manner or another, and the causes of resignation and delinquency must be studied intensively.

What then should members expect? Dr. Mervin J. Kelly, president of Bell Telephone Laboratories, has described the function of societies: "Engineering societies are repositories of the fundamental and applied technical knowledge of their fields and are agencies for its dissemination. Their meetings, publications, and committee activities crystallize thought on the technical problems of the engineering profession and insure that advances in technology become widely known and available for general application.

"They co-operate in establishing the necessary standards for our industry. They make large contributions to the professional status of engineering. Their numerous awards encourage invention and creativeness."

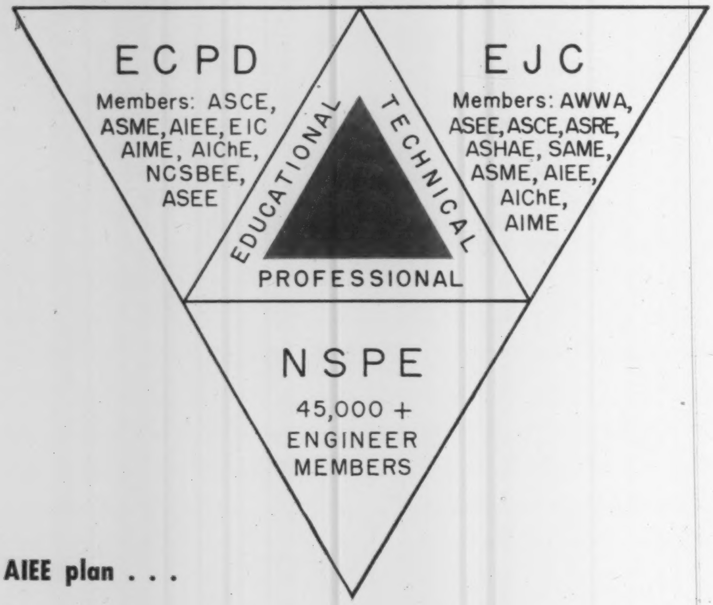
But engineers join societies for reasons of their own: 1. Societies provide the community of technical interest. 2. They keep members technically updated. 3. Membership brings with it an element of prestige. 4. Societies can effectively represent members in areas which they, as individuals, cannot reach.

An ASME poll of its members, taken several years ago, sheds some light on their attitudes. Of more than 20,000 replying, 55 per cent reported attending none of the previous year's meetings, and only 15 per cent claimed to have attended half or more of their section meetings.

Reasons were interesting. Main reason given for attending meetings was "interest in technical subjects" —for not attending, a noncommittal "other commitments." Queried on their choice of a subject for meetings, members voiced a strong preference for practical aspects as opposed to theoretical or commercial aspects.

Efficiency — 445%

Organizations outside the Founder Societies, such as the American Society for Metals (ASM), the Society of Automotive Engineers


ECPD
Members: ASCE, ASME, AIEE, EIC AIME, AIChE, NCSBEE, ASEE
EJC
Members: AWWA, ASEE, ASCE, ASRE, ASHAE, SAME, ASME, AIEE, AIChE, AIME
EDUCATIONAL
TECHNICAL
PROFESSIONAL
NSPE
45,000 + ENGINEER MEMBERS

AIEE plan . . .

for coordinating activities of engineering societies

(SAE), and the Institute of Radio Engineers (IRE), have also proved outstandingly successful. ASM, for example, manages to return $44.50 worth of services annually to its more than 30,000 members, in exchange for $10 annual dues.

Services to members include: 1. *Metal Progress*, monthly engineering journal. 2. *Metals Review*, monthly digest and review of all metals articles published throughout the world. 3. *Transactions*, annual volume of technical papers presented at the society's annual convention. 4. *Metals Handbook*, 1300-page reference work prepared by 2500 contributors, and updater supplements. 5. Home-study courses, for which 767 students enrolled within 15 months after inception of the program. 6. National Metal Congress, annual metal industry meeting. 7. National Metal Exposition, a tremendous commercial success held in conjunction with the National Metal Congress. 8. Books published by ASM at 20 per cent discount each year during joining time. 9. Employment Service, by which members' registrations are brought to attention of prospective employers, available to both members and employers at no cost.

Future program for ASM includes erection of a new headquarters building outside Cleveland, creation of a home-study division of their Metals Engineering Institute, and the creation of a division for metallurgical seminars. Tentatively planned for the future are a Metal Research Institute and a Metal Science University.

▶ Vertical vs. horizontal

Society of Automotive Engineers differs from many other technical societies in that its members are drawn almost entirely from a narrow group of industries, and they are not all engineers.

In a sense, SAE is a vertical type of organization in contrast to such horizontal societies as ASME, which consists almost entirely of mechanical engineers drawn from all types of industries.

Several years ago the society investigated the question of whether or not it should expand its subject coverage into areas of management or professionalism, but concluded it should "stick close to its knitting." Although it is strictly technical, SAE does not have such rigid qualification requirements as do other societies. Membership includes everybody from company presidents to owners of service agencies—from automotive designers to supplier salesmen. But SAE is most successful in disseminating technical information—and also in gaining interest of its members.

▶ Auxiliary targets

In addition to the technical engineering organization, special societies serve specific areas of interest to the engineer. The National Society of Professional Engineers (NSPE), founded in 1934 and numbering more than 45,000 members, devotes its entire effort to the professional, ethical, and social aspects of engineering. Its membership consists of registered professional engineers—common in public works and consulting-engineering organization, but less common in industry. The society concentrates on advancement of the engineering profession in the fields of employment practices, ethical practices, legislation, salaries and fees, military affairs, public relations, and education of young engineers.

Technical societies sometimes form intersociety associations. One such is the Engineers' Council for Professional Development (ECPD), made up of the Founder Societies and three others: the Engineering Institute of Canada (EIC), American Society for Engineering Education (ASEE), and the National Council of State Boards of Engineering Examiners (NCSBEE). ECPD seeks to advance the engineer professionally through the cooperative support of the member societies. ECPD over the years has been established as the recognized accrediting agency for engineering college curricula.

Still another type of engineering society is the Engineers Joint Council, a federation of 10 engineering societies. Composed of the Founder Societies and the American Water Works Association, the American Society for Engineering Education, the American Society of Heating and Air-Conditioning Engineers, the American Society of Refrigerating Engineers, and the Society of American Military Engineers, EJC acts as an advisory and co-ordinating agency and serves as a clearing house among technical societies.

▶ In pursuit of unity

AIEE last year advanced a plan for co-ordinating activities of engineering societies. The plan would assign responsibility for co-ordinating educational matters to ECPD, technical matters to EJC, and professional matters to NSPE. ASME's former president reported:

> In my meetings with the members and executive committees, a tremendous interest has been evidenced in achieving unity of the engineering profession. A meeting of eight presidents (ECPD, NSPE, EJC and the Founder Societies) initiated a movement which has far-reaching possibilities. In June, AIEE adopted a constructive policy aimed to reduce conflict, confusion and duplication of effort among the three principal agencies for unified action. While only a step *toward* effective unity, the policy is, I believe, a highly realistic one under existing circumstances . . .

However, ECPD has reported:

> The AIEE proposal of delineation of functions among ECPD, EJC, and the National Society of Professional Engineers is considered by many as a step toward unity. Other expressions of opinion have it to be a step backward.

The present tangled organization of independent engineering societies presents obvious deficiencies which the AIEE proposal seeks to eliminate. One major problem in today's society setup is that too often there are no clear-cut boundaries between engineering societies and no clear-cut lines of authority. Most telling charge leveled against societies from most engineers is they don't provide the effective leadership engineer members look for.

As central focal points about which engineers can rally for leadership in professionalism or in the setting up of engineering as a profession, they don't approach the effectiveness of such groups as the American Medical Association or the American Bar Association. At the same time, it must be observed that the road to distinct professionalism for engineers, most of whom are company employees, is far more difficult to navigate than for either doctors or lawyers.

The Intersociety Relations Committee of NSPE, re-examining NSPE's original negative position, recently went on record as favoring adoption of the plan and recommended to the NSPE Board that it approve the AIEE plan in principle. However, the requirement that NSPE open its membership to qualified engineers whose work does not by law require registration—as well as to registered engineers—has met with resistance by NSPE members, and will require further action at the state levels.

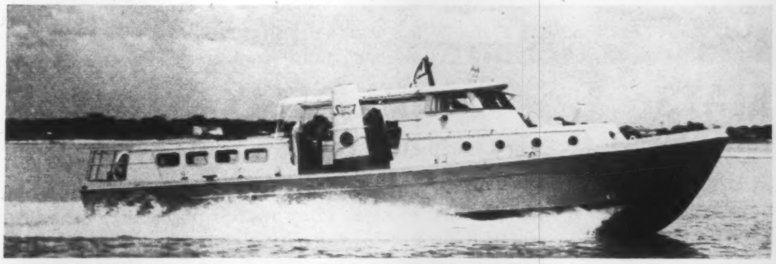
The committee emphasized the present excessive duplication of society activities and tabulated deficiencies which adoption of the AIEE proposal would remedy:

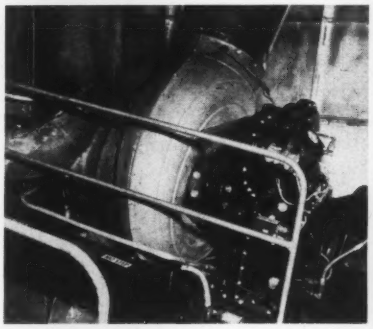
> Waste of members dues; waste of officers and committee time; dilution of the impact of these activities on their objectives; confusion in the minds of those at whom the activities are directed; and cancellation of the effect of these activities where two organizations may be working at cross purposes.

Under terms of the proposal, EJC would function primarily as a coordinating body for technical matters crossing the boundaries of the various disciplines. It would retain its interest in the recognition of specialties, honors for engineers, the National Engineers Register, and relations with corresponding bodies in foreign countries. EJC would, however, have to give up certain of its activities that bear on professionalism.

EPCD would continue its interest in the education and development of young engineers, the establishment of standards for engineering education, the accreditation of engineering curricula, and the canons of ethics. ECPD operations, under terms of the AIEE proposal, would not be affected to any great degree.

NSPE reports it has no activities that conflict with activities of either EJC or ECPD. It would continue activities relating to registration of engineers and economic considerations in the employment of engineers, including salaries and fees. NSPE alone would be responsible for formulating rules of behavior under the ECPD canons of ethics and for discipline under these rules.
—B. D. Ross





GAS TURBINES, designed for high horsepower, low weight, accelerate 55-ft boat from dead stop to 35 mph in 12 sec. The same boat using diesel power takes more than 1 minute to reach only 22 mph. The two 500-hp gas turbines, made by the Solar Aircraft Co. of San Diego, Calif., weigh a total of 4400 lb, about one-sixth the weight of diesels of equivalent power. The 55-ft crew boat, built by Sewart Seacraft of Berwick, La., can be easily converted to an offshore cruiser.

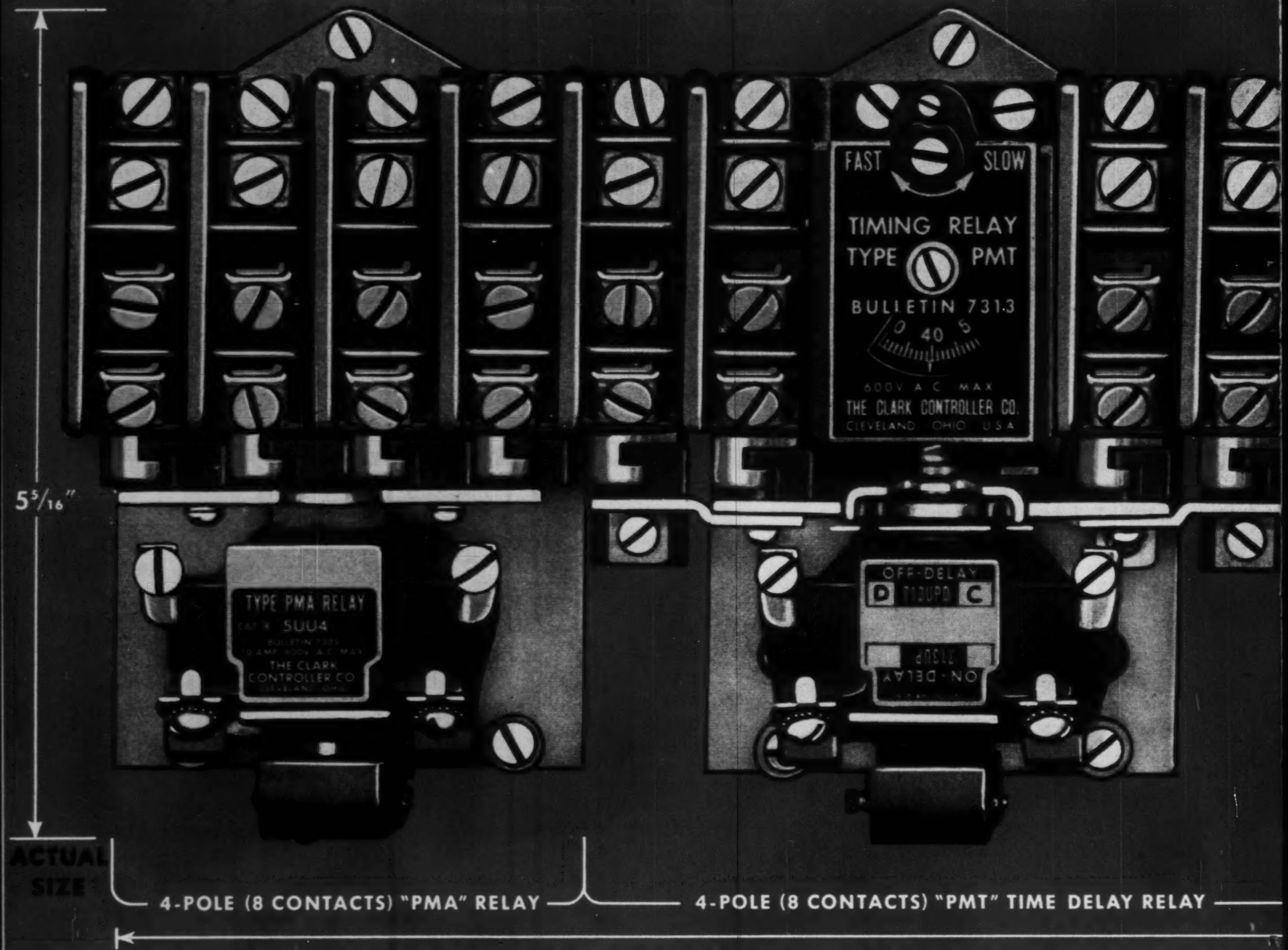
Transpolar Under-Ice Sub Used Celestial Navigation

GREAT NECK, N. Y.—For its history-making under-the-ice-pack transpolar trip, the *Nautilus* was equipped with the "most advanced navigational equipment ever assembled for underseas use," according to details revealed recently. Besides conventional gyro compasses, the submarine was equipped with automatic depth and course-keeping controls, a submarine celestial altitude recorder (SCAR), and an aircraft-type C-11 Gyrosyn compass system especially designed for use in polar regions, all developed by Sperry Gyroscope Co. of Great Neck, N. Y.

The *Nautilus*' SCAR permits celestial navigation while the ship is

(*Please turn to Page 28*)

NOW CLARK OFFERS: THE MOST COMPLETE INTEGRATED LINE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TYPE PMT
BULLETIN 731-3
600V A.C. MAX
THE CLARK CONTROLLER CO.
CLEVELAND OHIO U.S.A.
TYPE PMA RELAY
5UU4
THE CLARK
CONTROLLER CO.
OFF-DELAY
D
C
ON-DELAY
5⁵/₁₆"
ACTUAL SIZE
4-POLE (8 CONTACTS) "PMA" RELAY
4-POLE (8 CONTACTS) "PMT" TIME DELAY RELAY

UNIVERSAL POLE RELAYS

UP TO 14 CONTACTS PER RELAY

New Clark Universal Pole Relays now double the available number of contacts per relay. Each universal pole contains two isolated contacts—one normally open, one normally closed. Melamine barriers and spacing provide 600-v clearance between contacts. Contact specifications same as for other "PM" relays: 10 ampere rating, wiping action, same spring pressure and contact opening. Universal poles are interchangeable with convertible poles of "PM" relays. These relays, combined with the others shown above, now provide a range of integrated control relays covering practically every requirement, in minimum panel space.

Line up with other Clark relays on a panel!

TIME DELAY RELAYS

2 or 4 TIMED CONTACTS – up to 6 INSTANTANEOUS CONTACTS

New Clark Pneumatic Time-Delay Relays are designed for modern panels. They match physically other relays in the Clark "PM" line, with the same modular design. Timing head occupies the space of 2 poles above magnet. Universal poles each have isolated normally open and normally closed contacts, with 600-v clearance, saving panel space by doubling the number of contacts per pole. Timed and instantaneous poles are identical. Available for "ON-DELAY" or "OFF-DELAY" operation (time delay after energization or de-energization). Easily convertible by reversing magnet.

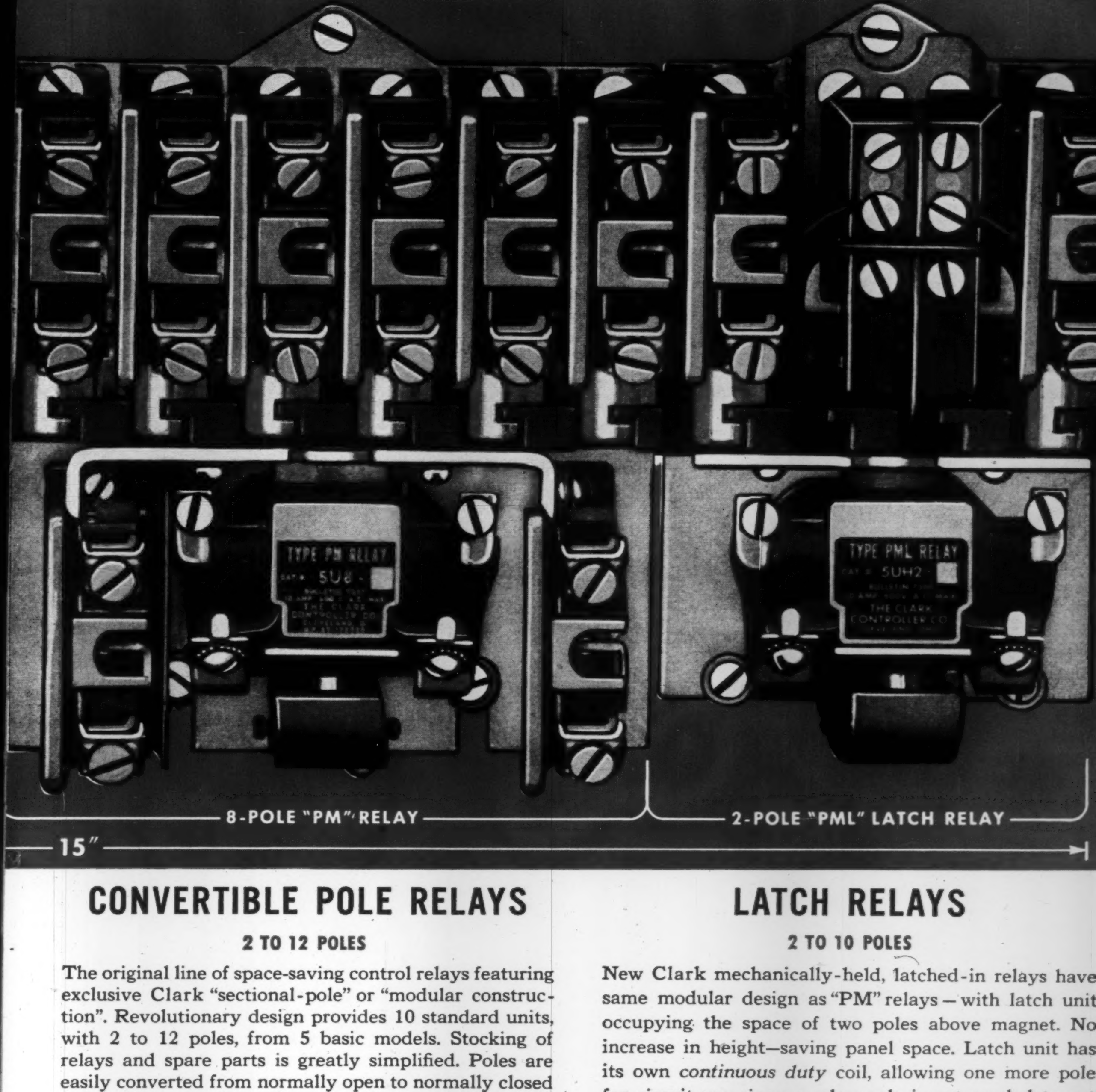
Line up with other Clark relays on a panel!

Write for Complete Information

Detailed descriptive bulletins are available for all relays in the Clark "PM" line. Contact your nearest Clark sales office or write us direct.

Circle 414 on Page 19

OF CONTROL RELAYS AVAILABLE TODAY!



CONVERTIBLE POLE RELAYS

2 TO 12 POLES

The original line of space-saving control relays featuring exclusive Clark "sectional-pole" or "modular construction". Revolutionary design provides 10 standard units, with 2 to 12 poles, from 5 basic models. Stocking of relays and spare parts is greatly simplified. Poles are easily converted from normally open to normally closed and vice-versa. Single deck models, with 2 to 8 poles, have identical mounting dimensions. Double-deck models, 6 to 12 poles, have mounting dimensions identical with NEMA size 1 starters. Individual poles are front removable without disturbing wiring.

Line up with other Clark relays on a panel!

LATCH RELAYS

2 TO 10 POLES

New Clark mechanically-held, latched-in relays have same modular design as "PM" relays—with latch unit occupying the space of two poles above magnet. No increase in height—saving panel space. Latch unit has its own *continuous duty* coil, allowing one more pole for circuit use since a relay pole is not needed to cut out coil when energized for sustained periods. As with all Clark relays illustrated, extra poles, coils, magnet assemblies and other components are available in kit form—a time saver for maintenance men.

Line up with other Clark relays on a panel!

The **CLARK CONTROLLER** *Company*

Everything Under Control — 1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO submerged. Because inertial navigation systems available today, such as that aboard the *Nautilus*, tend to "drift" over prolonged periods of time, there are obvious tactical advantages in a check system which permits navigational corrections while submerged. Details on the SCAR system, developed by Sperry's Marine Div., remain classified.

Portable Color TV System Will Operate from Batteries

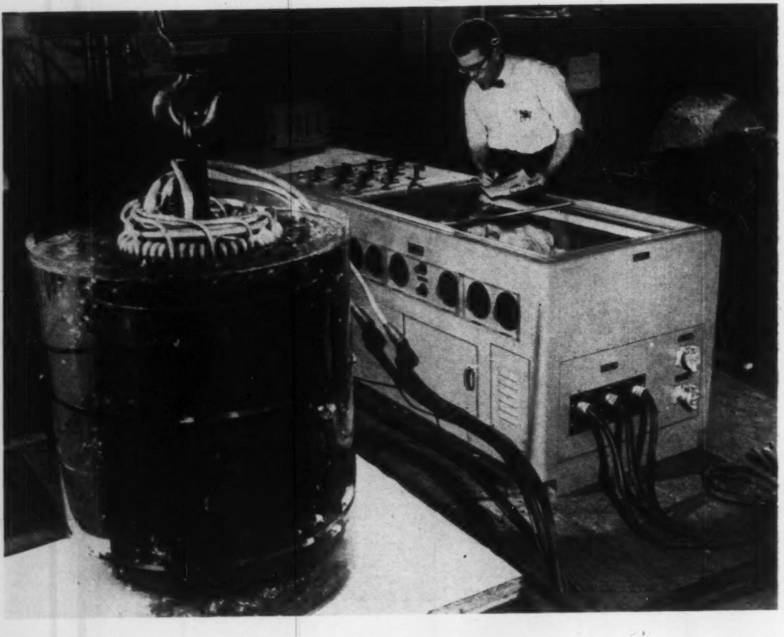
Developed For Closed-Circuit Use

New York—An experimental TV system contained in two compact units and weighing only 65 pounds has been developed by RCA. It uses less power than the headlights of an automobile and can be run either with batteries or a fixed power supply. The system is designed for closed-circuit applications and will see use in industry, defense, education, and research.

The two packages comprising the experimental system are a 20-lb camera that uses three developmental ½-in. Vidicon pickup tubes, and a 45-lb control and monitor unit about the size of a suitcase. The equipment uses more than 300 transistors, including several still in the developmental stage. The only vacuum tubes in the system are the three small Vidicon camera tubes and a black-and-white viewing tube for monitoring.

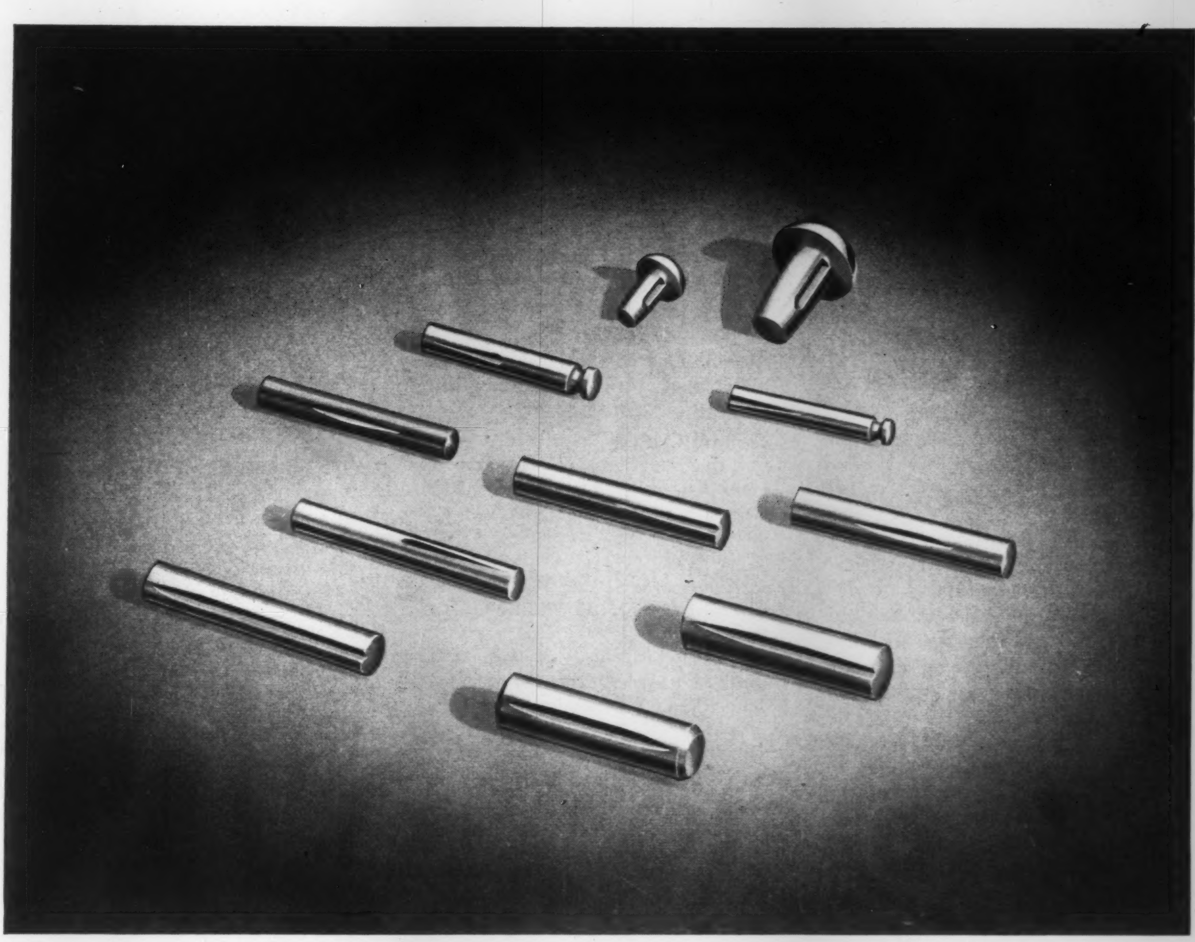
The laboratory system, like conventional closed-circuit equipment, includes a synchronizing generator and a colorplexer circuit to produce an NTSC color signal. Use of the new Vidicon tube permits the use of standard 8-mm motion-picture type lenses in the camera.

Among potential uses for the new system are certain types of classroom instruction, remote observation of industrial and research processes in which color is a controlling factor, field pickup for color telecasting, and military field reconnaissance. In each of these applications, portability and low power consumption—from batteries or from a fixed power supply—may be of major importance.



UNDERWATER MOTOR STATOR is tested by technician at the General Electric Medium AC Motor and Generator Laboratory in Schenectady, N. Y. The motor is designed to operate underwater with circulation through its windings, bearings, and magnetic components. A special insulation system using irradiated polyethylene protects the motor's components. "Wet" motors of 250 and 350 hp are currently being made for boiler circulating pump applications. In another application, requiring immersion of the motor in salt water, a 50-hp "wet" motor controls the rudder of a ship.

WATER SCOOTER can't be capsized even when the rider puts his entire weight on one side. The trim little craft, made in England and imported by the Nisonger Corp. of New Rochelle, N. Y., attains speeds up to 20 mph. It is fashioned of reinforced glass fiber and is controlled by the twist-grip throttle on the handlebar similar to a motor scooter.



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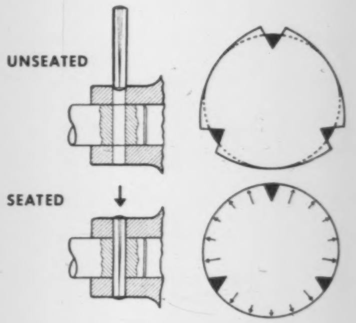
THE SOLID GROOV-PIN

Just drill the hole and drive the Groov-Pin home . . . once seated, it stays there, no matter what the conditions of shock and vibration. Yet it can be drifted out and reused with but little loss of its original holding power. No reaming is necessary. Available in nine different types, as well as in drive studs. Diameters from 1/32″ to 1/2″ and larger for special requirements, in a wide variety of materials. There's a Groov-Pin for every need, including the Type 3H for hopper feeding, and Types 6 and 7 for anchoring tension springs. Standard prices apply to specials in lots of 5000 or more.

Write today for free samples and the new 32-page Groov-Pin catalog... yours for the asking, it belongs in every designer's file of fastener reference literature. Address Groov-Pin Corporation, 1130 Hendricks Causeway, Ridgefield, N. J.



The unique GROOV-PIN locking principle

When a Groov-Pin is driven, the material displaced by the grooves is forced to flow back, setting up a powerful locking force. The ability of Groov-Pin to hold under severe shock and vibration . . . and its immunity to vibration fatigue . . . has been thoroughly proved by the billions in use!

GROOV-PIN

Circle 415 on Page 19

Outstanding Program Set for Mechanisms Conference

CLEVELAND, OHIO—Recognized authorities in mechanism design will present 19 papers during the Fifth Conference on Mechanisms at Purdue University, October 13 and 14. The unique two-day meeting, cosponsored by MACHINE DESIGN and Purdue's School of Mechanical Engineering, promises this year to have the most outstanding program in its history.

Purpose of the Conference is to promote better understanding of both theoretical and practical solutions in design and application of mechanisms.

This year's program will cover unique mechanism design techniques of value and interest to design and development engineers. In addition, the program also includes two talks by outstanding authorities on the personal and professional sides of engineering.

Registration is scheduled for 9 a.m. (Central Standard time) in Fowler Hall, in the new Memorial Center, on the Purdue Campus at Lafayette, Ind. Conference members will be welcomed at 10 a.m. by Prof. A. S. Hall Jr. of Purdue and Benjamin L. Hummel, associate managing editor of MACHINE DESIGN. Dr. Rudolf Beyer, eminent German mechanisms expert, will open the technical session with a survey of techniques, little known in this country, for analyzing motion properties of all types of 3-D mechanisms.

Complete program for the technical session is:

Monday, October 13

Registration: 9:00 a.m.
Fowler Hall, Memorial Center

10:00 a.m.—SESSION 1
Fowler Hall, Memorial Center
Chairman: Prof. R. S. Hartenberg, Northwestern University

Welcome and Orientation:
Prof. A. S. Hall Jr., Purdue University
Ben Hummel, associate managing editor, MACHINE DESIGN

European Report
. . . a brief rundown on Russian and East German Mechanism Conferences, the nature and significance of mechanisms developments in Europe. *Prof. J. Denavit, Northwestern University.*

Space Mechanisms
. . . a survey of 3-D mechanisms and techniques for analyzing their motion properties. *Dr. Rudolf Beyer, professor of kinematics and mechanism design, Technical University, Munich, Germany.*

1:30 p.m.—SESSION 2A
Room 206, Memorial Center
Chairman: Prof. H. G. Laughlin, Purdue University

Cycloidal Cranks
. . . characteristics and properties of crank mechanisms based upon cycloidal curves, with examples showing their advantages in high-inertia applications. *E. H. Schmidt, senior mechanical consultant, E. I. du Pont de Nemours & Co.*

Inflection Circle and Polode Curvature
. . . descriptions and applications of often-overlooked concepts and techniques for design and analysis of mechanisms. *Prof. A. S. Hall Jr., Purdue University.*

Applying the Inflection-Circle Concept
. . . the design of a lathe attachment for turning solids of revolution with approximately circular profiles. *Prof. James C. Wolford and Prof. Donald C. Haack, University of Nebraska.*

1:30 p.m.—SESSION 2B
Fowler Hall, Memorial Center
Chairman: Robert L. Stedfeld, associate managing editor, MACHINE DESIGN

Dynamic Analysis of Cam Mechanisms
. . . a numerical design procedure for relatively flexible systems—an extension of the method of finite differences. *Prof. Ray C. Johnson, Yale University.*

Cam Torque Curves
. . . an analysis of energy stored in the cam shaft, effect upon machine performance, and resulting suggestions for design. *Prof. Harold A. Rothbart, City College of New York.*

Pivoted-Follower Cam Systems
. . . a numerical method for obtaining cam profiles when follower motion cannot be reduced to an analytical expression. *Robert L. Droke, associate engineer, International Business Machines Corp.*

1:30 p.m.—SESSION 2C
Room 214, Memorial Center
Chairman: Prof. A. C. Dunk, Purdue University

A Mechanical Squaring Device
. . . the details of a unique, new mechanism for exact generation of the function, $y = px^2$. *Sigmund Rappaport, project supervisor, Ford Instrument Co.*

Mechanical Analog Computer Components—I
. . . a comprehensive survey of computer mechanisms and their functions, including principles of system formulation and error analysis. *George W. Michalec, section head, General Precision Laboratory, Inc.*

6:30 p.m.—BANQUET
Ballroom, Memorial Union Building

Tuesday, October 14

8:30 a.m.—SESSION 3A
Room 206, Memorial Center
Chairman: Prof. G. W. Bergren, Purdue University

Four-Bar Function Generators
. . . a group of linkages that generate common functions with minimum error, based on five-point approximations, and tables of characteristic data for them. *Prof. Ferdinand Freudenstein, Columbia University.*

Point-Position-Reduction
. . . a method for designing linkages to obtain desired correlation of input and output-crank positions at a limited number of positions. *C. Wesley Allen, engineer, General Electric Co.*

The Fecund Four-Bar
. . . how alternate linkages can be designed to produce coupler-point curves identical to the one traced by a known linkage. *Prof. R. S. Hartenberg and Prof. J. Denavit, Northwestern University.*

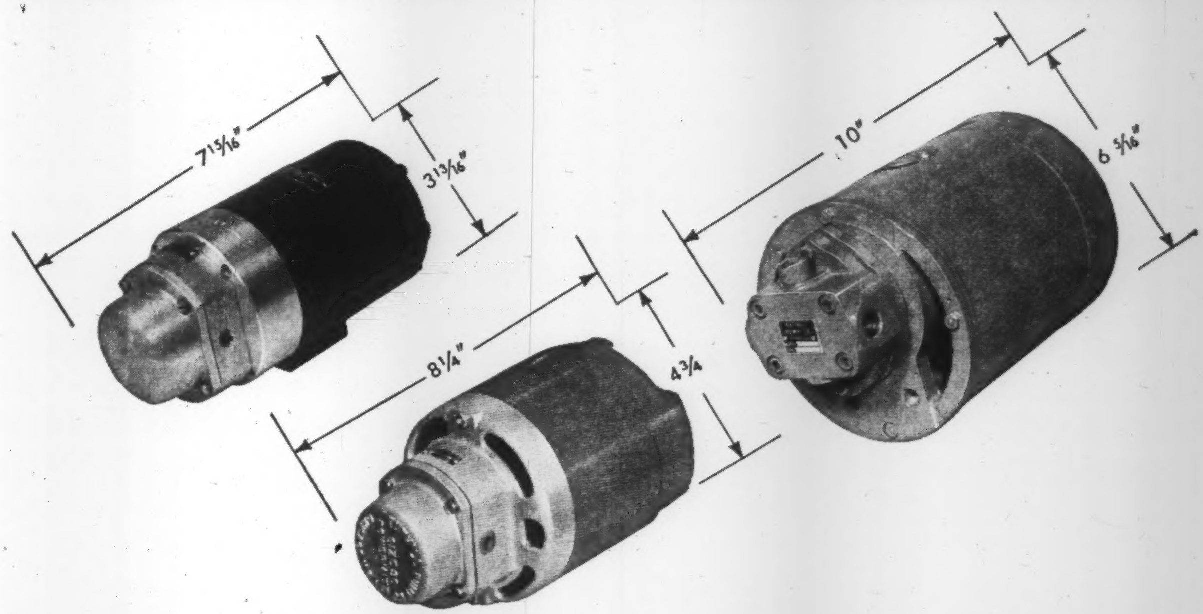
8:30 a.m.—SESSION 3B
Fowler Hall, Memorial Center
Chairman: Prof. A. R. Holowenko, Purdue University

Cam-Design Tables
. . . procedures and tabular data for the simplified design of a variety of practical cam profiles. *C. N. Neklutin, vice president, Universal Match Corp.*

Disc-Cam Curvature
. . . graphical and analytical methods for finding radii of curvature from instantaneous values of follower position, velocity, and acceleration. *J. Hirschhorn, school of mechanical engineering, New South Wales University of Technology, Sydney, Australia.*

High-Speed Spring-Actuated Cams
. . . how to obtain a prescribed output motion in a spring-driven system. *Philip Barkan, engineering research and development laboratory, Switchgear and Control Div., General Electric Co.*

Cut Product Costs with POWERMITE



custom engineered pump and motor combinations

More and more manufacturers are learning the economy of incorporating Tuthill's exclusive Powermite Pump and Motor Combinations in their products. These custom engineered units incorporate a specially designed electric motor into a rotary gear pump . . . to produce a combination unit which takes up no more space and weighs no more, than a conventional electric motor.

The Powermite's compactness solves tough design problems. Its small size and low weight make it easier to install . . . boost production line productivity. The elimination of bases, couplings and other parts result in substantial economies. Its lower weight reduces shipping costs. And all Powermites provide the long trouble-free, life which industry has learned to expect from Tuthill.

Wide range of combinations

A wide range of pump and motor combinations can be provided to meet individual requirements in hydraulics, lubrication, circulating, coolant, and other pump services. Three typical examples are shown above.

The compact unit to the left, developed for use on a small mobile hoist, combines an internal gear pump rated for 30 cu. in./min. at 500 psi, with a 1/8 hp motor. The center unit, developed for a low pressure hydraulic application combines an internal gear pump with a capacity of 16 gpm at 250 psi with a 1/12 hp motor. The unit at right combines a high pressure hydraulic spur gear pump, for rated conditions of 1 gpm at 1,000 psi with a 3/4 hp motor.

Custom engineered for your application

Each Powermite model is custom engineered for a specific OEM application and is designed to permit substantial economies for high volume production. A few Powermite models are available from stock—for example, the 350 psi, 16 gpm model shown at center above. For small quantity applications Tuthill Close Coupled Pump and Motor Combinations can provide similar savings.

Manufacturers interested in learning more about the advantages of incorporating Powermite combinations into their products are invited to forward detailed specifications. Or, if preferred, a Tuthill Field Engineer will call.

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NFPA NATIONAL FLUID POWER ASSOCIATION

8:30 a.m.—SESSION 3C

Room 214, Memorial Center
Chairman: Ben Hummel, associate managing editor, MACHINE DESIGN

Mechanical Analog Computer Components—2

. . . the second part of an extensive discussion of computer mechanisms, accenting their potentials in other applications. *George W. Michalec, section head, General Precision Laboratory Inc.*

Noncircular Gears

. . . how they can be designed and applied effectively in function-generating applications. *F. W. Cunningham, president, Cunningham Industries Inc.*

12:15 p.m.—LUNCHEON

Ballroom, Memorial Union Building

1:45 p.m.—SESSION 4

Fowler Hall, Memorial Center
Chairman: Leo F. Spector, associate editor, MACHINE DESIGN

Measurement as a Design Tool

. . . approaches, techniques, equipment for analyzing dynamic behavior which must be eliminated or controlled in a successful design. *F. E. Fisher, manager, Electrical Analysis and Mechanical Analysis Lab., International Business Machines Corp.*

Micromotion Analysis via High-Speed Movies

. . . equipment and techniques for studying mechanism performance qualitatively and quantitatively. *William G. Hyzer, consulting research engineer, Janesville, Wis.*

General Discussion

. . . an "open-forum" period headed by conference co-chairmen Hall and Hummel.

Advance registration and room reservations for the Conference may be made by using the form which appears on Page 205 of this issue. For additional information, write to Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Modify Fractional-Hp Motors To Simplify Application

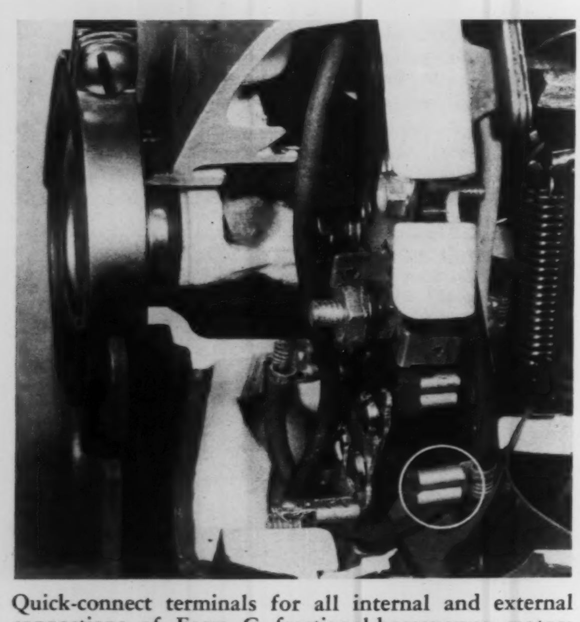
SCHENECTADY, N. Y. — Major changes in Form G fractional-horsepower motors, made by General Electric Co., will halve wiring time, permit quick change of rotation, and cut operating noise, according to company officials.

New features include plug-in quick-connects for all terminals, quick change of rotation by reversal of the two plug-in motor leads, and brass links that simplify voltage change on dual-voltage motors. An antirust treated shaft, a built-in lug for convenient grounding connection, and a composition washer in the centrifugal switch for quiet operation are other significant changes.

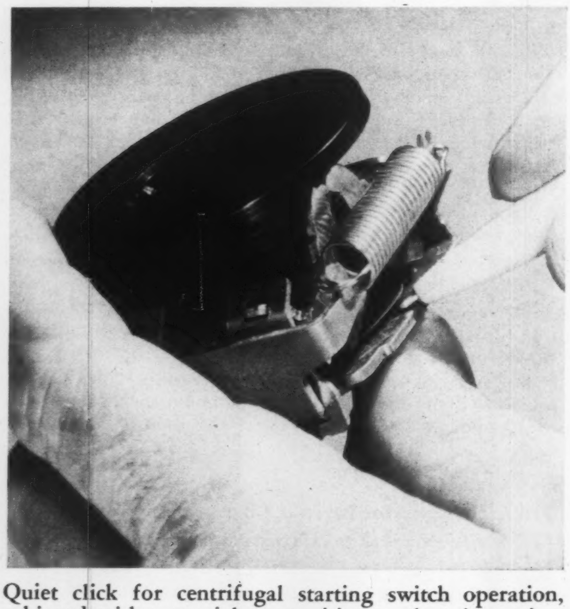
Wiring time during installation can be cut in half with the plug-in quick-connect terminals which are used for all internal and external connections, according to company engineers. Studs have been retained on the terminal board for conventional wiring if the quick-connect devices are not used.

Shaft rotation can be reversed in a matter of seconds without tools by interchanging two plug-in motor leads. Voltage change on dual-voltage motors is easily accomplished by sliding two small brass links into position. The operation can be performed with a screwdriver without removing the links by adjusting four screws and sliding the interlocking connections into place.

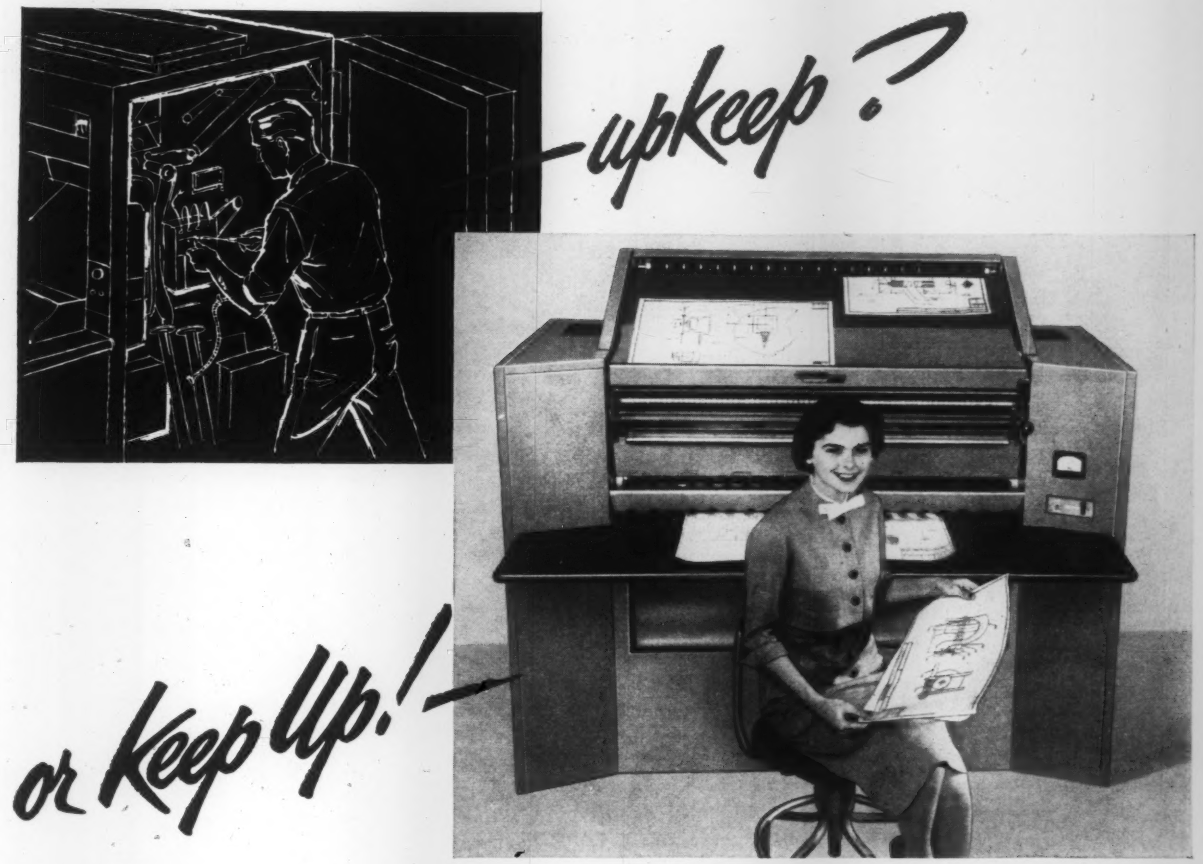
Ground connection can be made conveniently with a new lug designed into the end shield just inside the terminal box opening. The built-in lug is easily reached for connecting a grounding conductor necessary in applications such as sump pumps, home workshop tools, power lawn mowers, and some farm equipment.



Quick-connect terminals for all internal and external connections of Form G fractional-horsepower motors halve wiring time during installation.



Quiet click for centrifugal starting switch operation, achieved with a special composition washer, is particularly desirable for residential applications.



Model 35. Moderately priced machine for volume reproduction. Provides up to 30 f.p.m. speed and full 46-inch printing width.

WHY put up with upkeep, downtime, and aggravations of older reproduction equipment? You can *keep up* the efficiency of your drafting department—and be money ahead—by replacing older units with new, modern Copyflex machines.

Take a moment to compare the performance of your equipment with these modern reproduction advantages. Can you really afford *not* to keep up with Copyflex?

More Operator Conveniences. Modern Copyflex gives printing widths up to 54″ to simplify feeding of large tracings, facilitate multiple feedings. Extra-large delivery trays, automatic separation, automatic stacking, and front-or-rear delivery further speed operator's work.

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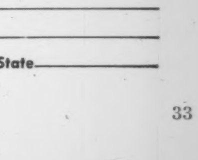

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Circle 417 on Page 19

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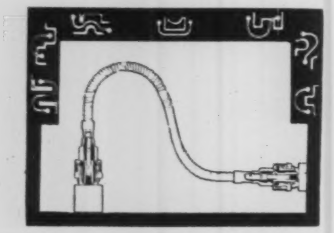


The Flexible Shaft today, although not complicated, is a specific component designed for specific applications. Industry in many fields, i.e., automotive, automation, aircraft, electronics, radio and television, machinery, and marine (to name but a few) have found flexible shafting to be more economical and yet more productive than whatever means they were employing to control motion from one unit to another where obstacles in the path of installation were impossible to do away with.

There are two types of flexible shafts. One is the power drive flexible shaft which utilizes a cable wound to rotate in one direction only. The outer layer of wire of the cable determines the direction rotation, and is wound so that the slack is taken up when the shaft is in operation, making it practically impossible for the cable to spring from its original shape. The other type is the remote control flexible shaft in which the cable is wound so that the slack is taken up no matter which direction the shaft is turned. The remote control shaft provides for both rotation and reciprocation, such as the opening and closing of a valve.

● ● ● For complete information as to how flexible shafting may help you solve your specific control problem, write F. W. Stewart Corporation, 4311-13 Ravenswood Ave., Chicago 13, Illinois.

Circle 418 on Page 19

High-Temperature Uses Seen For Composite Laminated Plastic

NORRISTOWN, PA.—Preliminary tests indicate that a new composite laminate plastic holds distinct promise for very high temperature applications. Use in missile nose cones is definitely conceivable, since 5-min tests with the new material show that it conducts about 25 per cent less heat from surface to interior than the most effective homogeneous material tested. Surface temperature during tests was 2000 F.

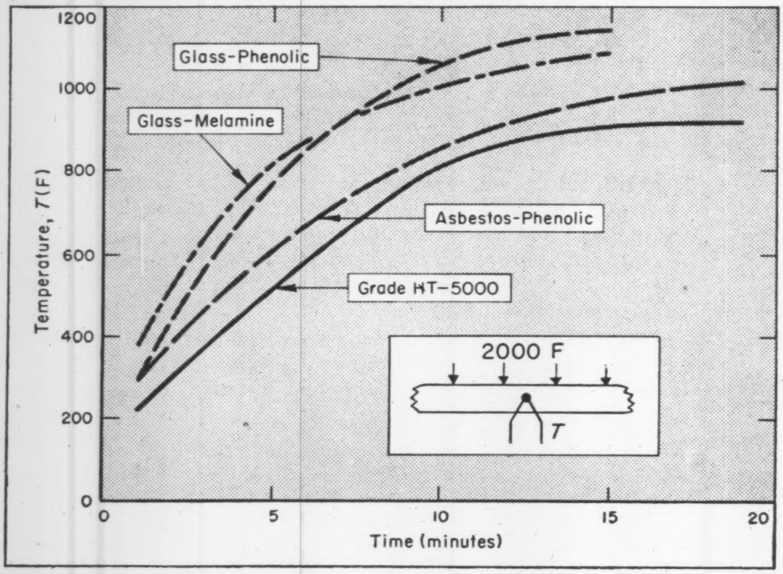
According to Taylor Fibre Co., Norristown, Pa., the unique thermal properties of the composite material have opened a new field of investigation which may radically change existing concepts about the behavior of laminated plastics.

As a case in point, Taylor engineers found that the physical, mechanical, and electrical properties of composite laminates can be sharply altered not only by combining different base laminates, but also by varying the proportion of the components in the composite material. The possible combination of properties is almost limitless.

The high-temperature laminate resulting from the initial research is made by alternating layers of two materials: One is an asbestos-mat base impregnated with a special phenolic resin; the other, a nylon fabric impregnated with this same phenolic. The composite material is called grade HT-5000.

Thermal insulation tests made on the new laminate show a definite improvement over asbestos-base laminates and even greater improvement over glass-laminates.

The superior thermal insulation is attributed to the lower density of the impregnated nylon layers. Nylon also carbonizes, making the material erosion resistant. In addition, the material has the ability to generate gas on heating. All of these properties prevent excess heat from penetrating from the surface to the interior of the laminate, thus preserving its structural strength.



Comparative thermal insulating properties of composite asbestos-phenolic, nylon-phenolic laminated plastic (grade HT-5000); asbestos-phenolic laminate; glass-melamine laminate; and glass-phenolic laminate. Tests were conducted by embedding a thermocouple in the center of 1/4-in. thick sheets of the materials, applying heat of 2000 F to the surface of the sheets, and measuring the temperature in the center at half-minute intervals.

Demand for six-cylinder cars during the first six months of 1958 was more than double that of the corresponding period last year, according to Dodge Division, Chrysler Corp. From January through June, 1957, the demand for the Dodge six represented 4.6 per cent of production compared to 9.7 per cent for the same period in 1958.

Free College Training Available To Gov't. Scientists, Engineers

WASHINGTON — House-Senate conferees have agreed to House revision of a federal employee training bill previously approved by the Senate during the first session of the present Congress. The bill provides that the Civil Service Commission will have the primary authority and responsibility over the training program. Under the program Government employees can receive training both within and outside the Government where such training is in the public interest. The Government will pay the full expenses including travel, tuition, books and supplies, and during the training period the employee will receive his regular salary.

Each employee trained at a nongovernment facility must agree to serve for a period at least equal to three times the length of the period of his training. In addition, employees are limited to one year of training at nongovernment facilities in each ten years of employment. The bill specifically prohibits training at outside facilities for the sole purpose of obtaining academic degrees, or to obtain academic degrees to qualify for appointment to a position.

The authorization for advanced training should prove especially beneficial to federal engineers and scientists. In its report on the bill, the House Civil Service Committee stated:

> "One of the most serious problems caused by the lack of a sound Government employee training program relates to the recruiting and retaining of scientific, engineering, professional, and technical skills for space research and development and for the national defense. Opportunity to continue and broaden knowledge and qualification, not only is in the public interest, but also constitutes one of the major objectives of scientific and professional personnel. Shortcomings in the Government's training policies have impeded progress by the Government in these endeavors by destroying one of the finest possible incentives for outstanding scientists and professional people to devote their careers to the public service. This delegation will remove this impediment, restore incentive, and bring a

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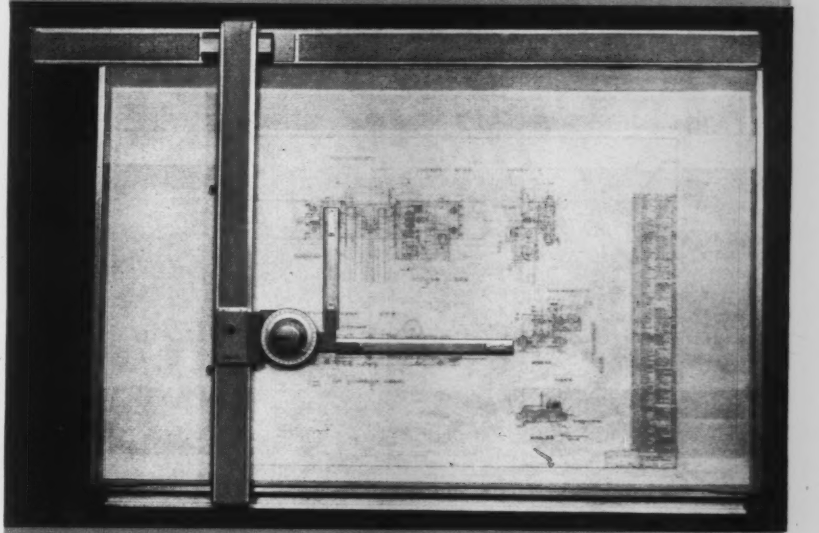

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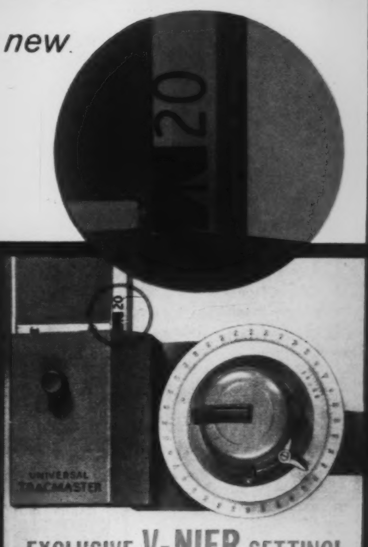

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"Vitality" is an important characteristic of Chatillon Torsion Springs, insuring continuous, fool-proof actuation of critical instrument components such as shutter devices, rotors, etc.

For this reason—and because Chatillon Torsion Springs are accurately calibrated to meet the strictest torque requirements—leading instrument manufacturers specify Chatillon Torsion Springs in their designs. Manufacturers include Fairchild Camera and Instrument Corp., Sperry Gyroscope Co., Bulova Research & Development Corp., and many others.

Chatillon makes Torsion Springs in all the conventional alloys as well as in Chatillon's unique temperature-compensated material Iso-Elastic* (virtually unaffected by temperatures from −50°F. to +150°F.)

Call on Chatillon's Spring Division for their experienced assistance with your designs. Write for engineering bulletins.

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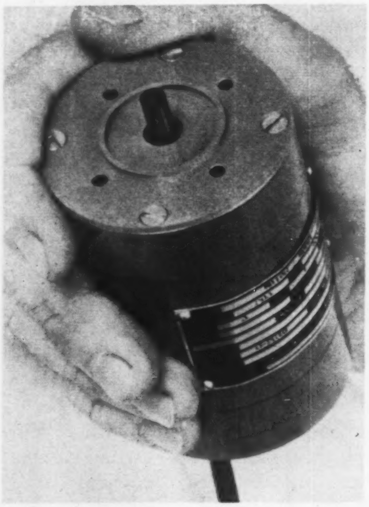
Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

Circle 420 on Page 19

> desirable measure of prestige to scientific and professional assignments under essential government programs. . . ."

The new legislation is expected to be of considerable help to the Government in recruiting and retaining high-caliber personnel.



HIGH POWER-SIZE RATIO is an outstanding feature of this lightweight ac motor used in missile applications. Developed by Hoover Electric Co., Columbus, Ohio, the motor is rated 1-hp, but will produce a maximum 1.75 hp at 22,000 rpm. It weighs 2¾ lb and is 4 in. long by 2½ in. in diameter. Electrical specifications: 400 cps, 208 v, 3 phase. Mounting flange and shaft configuration are optional. Shaft can be pinion gear, flat, splined, or other desired shape.

"Package" Reactor Goes Critical

LEMONT, ILL.—Prototype of a nuclear reactor designed to produce electric power and space heat at remote military stations, the Argonne Low Power Reactor (ALPR), achieved criticality recently at the AEC's National Reactor Testing Station in Idaho. The prototype is undergoing tests prior to operating at full power of 3000 thermal kw.

The ALPR is a "package" plant designed to be erected on any type of terrain with a minimum of onsite construction. Heat from the reactor can be used to generate 260 kw of electricity and 400 kw of space heat. Electrical output of ALPR plants at military sites would be used to supply power for radar equipment and the space heat for offices, barracks, and other buildings.

The reactor is designed to operate for three years with each fuel loading. This prolonged operating period simplifies the task of operating isolated plants by eliminating the need for delivery and storage of large quantities of conventional fuel.

Meetings

AND EXPOSITIONS

Sept. 21-24—
American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Cosmopolitan Hotel, Denver. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

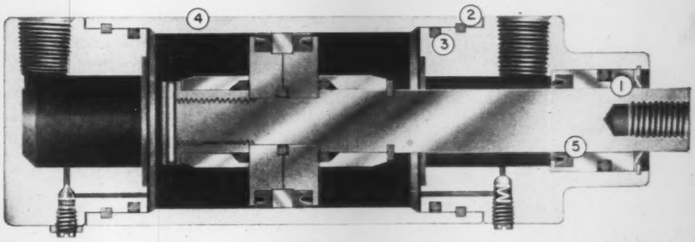
Sept. 22-23—
Steel Founders' Society of America. Fall Meeting to be held at The Homestead, Hot Springs, Va. Further information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 22-24—
Institute of Radio Engineers. National Symposium on Telemetering to be held at the Americana Hotel, Miami Beach, Fla. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Sept. 22-24—
Standards Engineers Society. Seventh Annual Meeting to be held at the Benjamin Franklin Hotel, Philadelphia. Further information can be obtained from Mr. C. W. Bowler, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa.

Sept. 22-24—
Material Handling Institute Inc.

CARTER
CYLINDERS
AIR OR HYDRAULIC



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THE CARTER DESIGN
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2—Key type stainless steel locking ring. Allows 360° rotation of ports.
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4—Precision honed heavy wall tubing—6 to 1 safety factor.
5—Spring loaded "V" packing on rod end gland.
IMMEDIATE DELIVERY FROM STOCK

SAVINGS IN SPACE—40% savings in space. Helps build more compact, functional equipment. Where other cylinders won't fit, Carter will!

IMPROVES PRODUCT QUALITY Carter cylinders are stronger, more efficient. Completely leakproof! Better performance, longer life. The finest cylinder for your product.

ENGINEERING SERVICE and sales in 40 locations throughout the United States, Canada, Mexico, and Europe.

FREE DESIGNERS' FILE
Details on air, hydraulic, valves, built-in-valve types. All necessary data for designers.

CARTER CONTROLS INCORPORATED
24 Bernice Road • Lansing, Illinois (Chicago Suburb)
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AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

Circle 421 on Page 19

Fall Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

Sept. 23-26—
Association of Iron and Steel Engineers. Iron and Steel Exposition and Convention to be held at the Public Auditorium, Cleveland. Further information can be obtained from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 24-25—
Seventh Annual Conference on Industrial Electronics to be held at the Rackham Memorial Bldg., Engineering Society of Detroit, Mich. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Additional information can be obtained from Mr. H. W. Patton, Acromag Inc., 22519 Telegraph Rd., Detroit 41, Mich.

Sept. 25-27—
Porcelain Enamel Institute. Annual Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Further information can be obtained from PEI headquarters, 1145 19th St., N. W., Washington, D. C.

Sept. 29-Oct. 1—
National Power Conference to be held at the Statler-Hilton Hotel, Boston. Sponsors are the power divisions of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. Additional information can be obtained from ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 29-Oct. 3—
Society of Automotive Engineers. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display to be held at the Ambassador Hotel, Los Angeles. Additional information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Sept. 29-Oct. 3—
American Society of Tool Engineers. Semiannual Meeting and Western Tool Show to be held at the Shrine Exposition Hall, Los Angeles. Further information can be obtained from ASTE headquarters, 10700 Puritan Ave., Detroit 38, Mich.

Oct. 7-8—
Institute of the Aeronautical Sciences — Canadian Aeronautical Institute Joint Meeting to be held at Chateau Laurier, Ottawa, Canada. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Oct. 8-10—
Gray Iron Founders' Society. Annual Meeting to be held at the Sheraton Park Hotel, Washington, D. C. Further information is available from society headquarters, National City-E. Sixth Bldg., Cleveland 14, Ohio.

Oct. 8-10—
Industrial Designers Institute.

45 master keys to

Type 302*
Type 304
Type 304L
Type 309S
Type 309Cb
Type 310
Type 316
Type 316L
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Type 317
Type 317L
Type 330
Type 321
Type 347
Type 348
Type 410
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Type 442

Type 443
Carpenter 7Mo (329)
Carpenter Stainless No. 20Cb
Titanium 40, 55 and 70
Zirconium
Zircalloy II & III
19-9DL & DX
Invar 36
HyMu 80

Multimet Alloy (N-155)
Haynes No. 25 (L-605)
Hastelloys B, C, F & X
Armco 15-7Mo PH
Armco 17-7PH
A-286
16-25-6
Type 201
Type 202
Low Expansion "42" and "49"

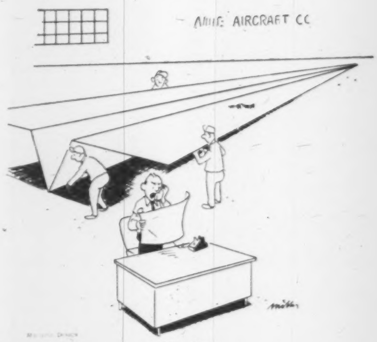
available through representatives and distributors in over

Design Materials Show to be held concurrently with the annual National Conference of IDI at the Sheraton-East Hotel, New York. Additional information can be obtained from Mr. Leonard Rogers, Orkin Expositions Management, 19 W. 44th St., New York, N. Y.

Oct. 13-14—
Fifth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Further information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Oct. 13-15—
American Institute of Electrical Engineers Tenth Annual Machine Tool Conference to be held at the Statler-Hilton Hotel, Hartford, Conn. Additional information can be obtained from Mr. William P. Carpenter, Superior Electric Co., 83 Laurel St., Bristol, Conn.

Oct. 13-15—
National Electronics Conference to be held at the Hotel Sherman, Chicago. Sponsors are American Institute of Electrical Engineers, Institute of Radio Engineers, and Illinois and Northwestern Universities. Additional information can be obtained from Rudolph E. Hornacek, Illnois Bell Telephone Co., 208 W. Washington St., Chicago 6, Ill.



" Get me the engineering department."

Oct. 16-17—
National Conference on Industrial Hydraulics to be held at the Hotel Sherman, Chicago. Further information can be obtained from Raymond D. Meade, Director of Extension and Co-operative Education, Illinois Institute of Technology, 3300 S. Federal St., Chicago 16, Ill.

Oct. 16-18—
Foundry Equipment Manufacturers Association. Annual Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Additional information is available from association headquarters, 1 Thomas Circle, Washington 5, D. C.

Oct. 27-31—
American Society for Metals. National Metal Exposition and Congress to be held at the Public Auditorium, Cleveland. Additional information can be obtained from ASM headquarters, 7301 Euclid Ave., Cleveland 3, Ohio.

cost-saving corrosion control

• Whatever it takes, Carpenter makes in stainless and high alloy tubing and pipe to most effectively and economically combat most corrosive agents. On the opposite page is a wide variety of standard and special-purpose analyses that can be supplied.

What's more, you get predictable performance in all *full finished* Carpenter corrosion-resistant tubing and pipe . . . it fully meets the high quality requirements for heat exchanger service. No short-cuts . . . no false economy . . . just the kind of on-the-job service that saves you operating dollars.

You can save up to 40% in first-cost dollars by using Carpenter stainless and high alloy tubing and pipe. Their overall consistent uniformity of O.D., I.D., gauges and physical properties assures you trouble-free, time-saving fabrication and installation.

Whatever your corrosion problem . . . ordinary or unusual . . . you'll get the right answer at Carpenter—"The House of Corrosion Control". You'll benefit from over 30 years' experience in helping industries and equipment builders to solve a vast assortment of problems.

Readily available to you are data on any specific alloy you're interested in, or our Selecting and Buying Guide to your 45 master keys to cost-saving corrosion control. Contact our nearest office or authorized distributor, or write direct to The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

more than corrosion resistance

Carpenter

stainless tubing & pipe

40 cities . . . coast to coast

Circle 422 on Page 19

Another new fastener idea by Parker-Kalon

SPINNERS?

Screws on the floor mean trouble at your door! Ordinary fasteners when used in the assembly of thin gage metal sheets, often spin or slip—result in work stoppages, salvaging operations, higher production costs.

Now you can substantially reduce waste motion, rejects and lost time, with Parker-Kalon's new "*Hi-thred*" Self-tapping Screw . . . the new fastener that *grips securely without spinning or slipping* . . . even in very thin gage metal sheets.

Developed by P-K's research team, the revolutionary "*Hi-thred*" is THREADED FULL TO THE HEAD —WITH THE LAST THREAD ACTUALLY TERMINATING IN AN ANNULAR ORIFICE IN THE HEAD ITSELF!

For samples, see your nearby Industrial Distributor or write P-K direct. "*Hi-thred*" fasteners are available in production quantities in Types "A" and "Z" in non-countersunk head styles.

PARKER-KALON® "Hi-thred"

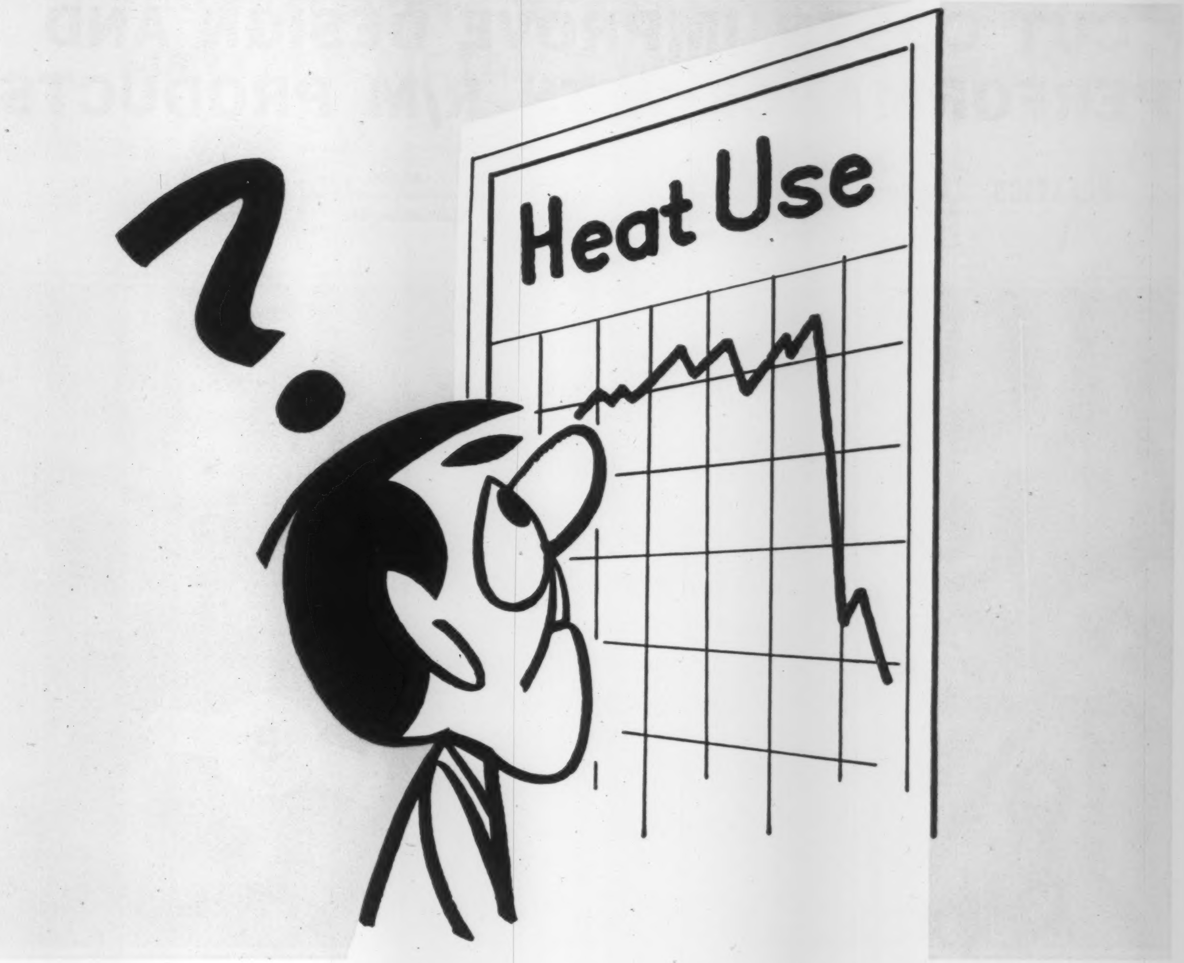
Pat. Pending

Self-tapping Screws

Sold everywhere through leading Industrial Supply Distributors

PARKER-KALON DIVISION, *General American Transportation Corporation, Clifton, New Jersey*

Circle 423 on Page 19



THE CASE OF THE PUZZLED ENGINEER

(A Cold Bonderite* Story)

The plant heating engineer, wondering at the diminished demand on his heating plant, set out through the plant to find the cause. All was normal until he met the finishing superintendent. "Haven't you heard?" asked that happy gentleman. "We've installed Cold Bonderite* in our finishing line. Steam use is down 90% and water use is down 50%!"

***"Cold Bonderite" is the commonly used term for a phosphate coating system developed by and exclusive with Parker Rust Proof Company. Its use is saving many manufacturers thousands of dollars a month.**

Since 1914— leader in the field

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

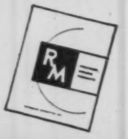
BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite, —Reg. U.S. Pat. Off.*

Circle 424 on Page 19

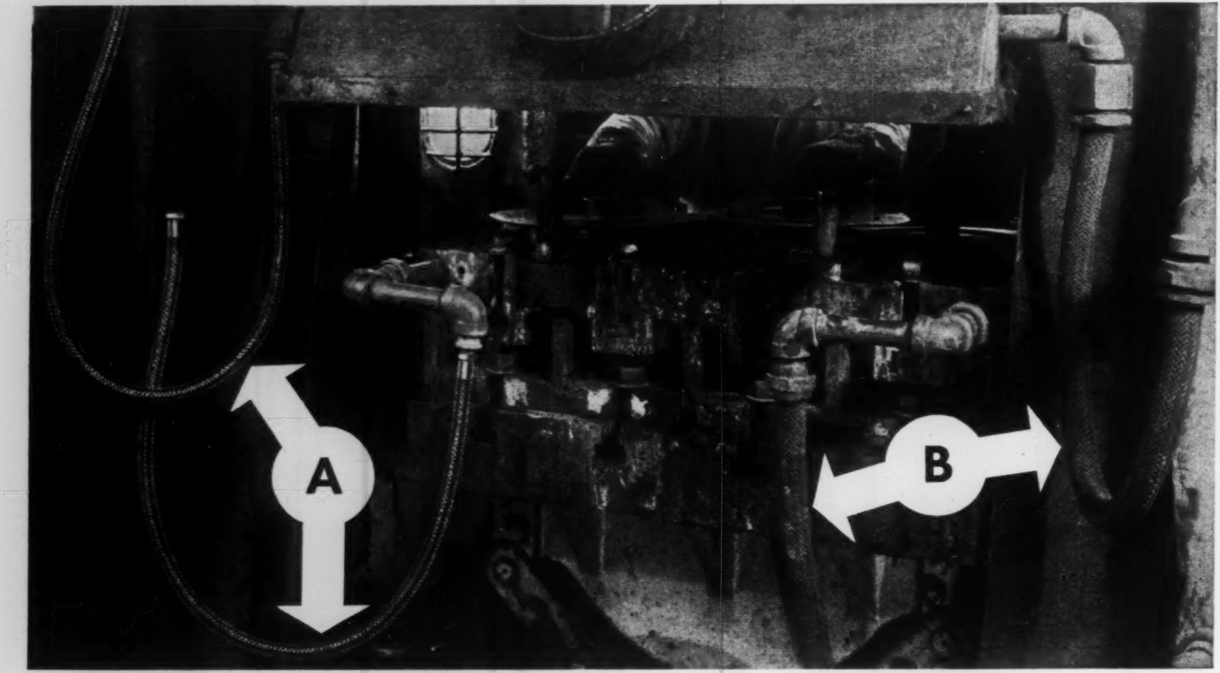
CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

PLASTICS



Write for booklet, which provides valuable information on a variety of R/M "Teflon" products.

Plastic Products Division, Raybestos-Manhattan, Inc.
Manheim, Pa.



Steam lines to hydraulic press. (A) Wire-braided R/M "Teflon" hose—no failure due to corrosion or normal wear since installation in 1955. (B) Old-type wire-braid reinforced corrugated metal hose—has had to be replaced every 4 months.

R/M will do a better job in tailoring Teflon* to your needs

Here's a graphic illustration of the superiority of R/M "Teflon" over ordinary materials. The larger diameter of the clumsy metal hose is to compensate for the space needed for the corrugated hose wall and its relatively rough inside surface. Consider the big savings in labor and materials costs resulting from the use of R/M "Teflon" hose!

Raybestos-Manhattan has had years of experience in working with "Teflon". . . in making the most of its unique characteristics. Our technicians and the laboratories they work in have an outstanding record of achievement in the development and testing of products made from this versatile material. R/M's production facilities are unsurpassed. Together, they tackle the "it-can't-be-done" assignments in stride.

R/M's reputation for leadership in "Teflon" rests soundly on the products and processes it has developed, the problems it has solved. Our comprehensive know-how and complete facilities qualify us to supply *all* your "Teflon" needs, no matter how exacting. Make us your headquarters for every "Teflon" product, from sheets, rods, tubes, tape and hose to complex molded and machined parts painstakingly fabricated from your specifications. (We supply wire-braided R/M "Teflon" hose in uncoupled lengths only—get coupled lengths you need from leading hose assemblers.) For further information, call or write Plastic Products Div., Raybestos-Manhattan, Inc., Manheim, Pa.

*A Du Pont trademark

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

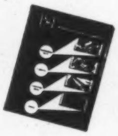
Industrial and Automotive Hose

Conveyor Belts

Circle 425 on Page 19

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

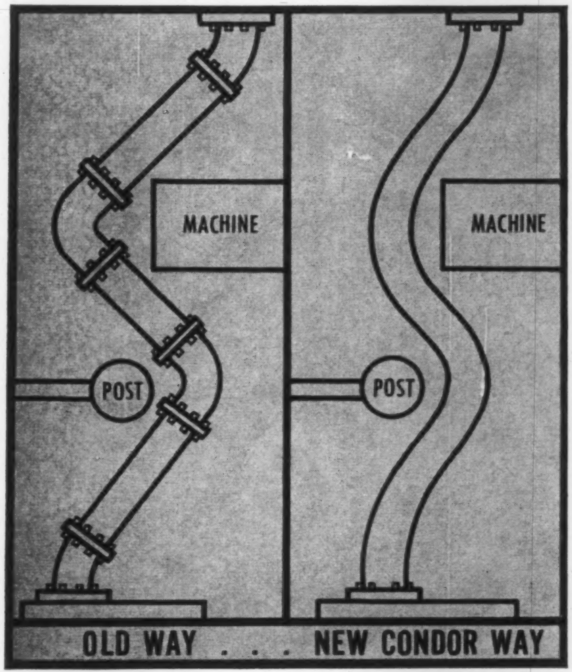
RUBBER



Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division, Raybestos-Manhattan, Inc.
Passaic, N.J.

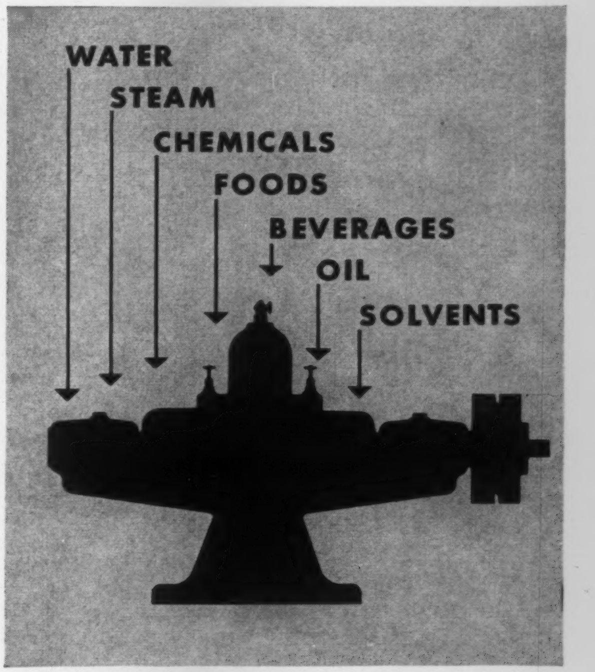
PACKINGS

Write for free booklet giving complete information on R/M Plastic Packings.
Packing Division, Raybestos-Manhattan, Inc.
Passaic, N.J.



Condor Rubber Pipe—tough, light, flexible

Where corrosion, abrasion, vibration or contamination means trouble with iron or steel pipe, versatile Condor Flexible Rubber Pipe is your solution. It actually outlasts other conventional piping in handling coal or coke breeze, ashes, finely broken up materials and many slurries, corrosive liquids and caustic solutions. Whatever the application, Condor Flexible Rubber-Pipe goes where you want it to go . . . eliminating fabricated, leaky joints and cumbersome supports. Raybestos-Manhattan also makes to your special order rubber expansion joints, rubber-lined pipe, fittings and process equipment, acid hose, rubber covered rolls. You can depend on R/M also for rubber hose, transmission belt and V-belts, Poly-V drives, conveyor belt, molded and extruded rubber products. Rubber specialists since 1893.



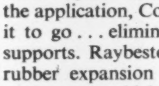
Two R/M Plastic Packings—R/M Universal and R/M "versi-pak"®—answer the designer's problem of lower friction and longer wear

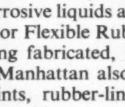
These superlative R/M packings have features that will pay off in every pump and valve you design. Both are custom made for low friction and for maximum resistance to heat, materials handled, and pressure. Locked-in lubrication and soft, open-fiber asbestos combine to reduce wear on rods and valve stems, even after long service.

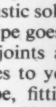
In Universal Plastic Packing, R/M has combined asbestos fiber and graphite with lubricant and binder. Designed for all types of circulating, reciprocating and centrifugal pumps. Types are also available for oil and for food processing equipment. R/M "versi-pak" is similar in composition, but has a special solvent-proof binder that makes it ideal for solvent installations up to 350 F and 600 psi. Send for complete data for specific recommendations.

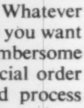
RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

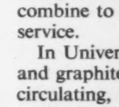

Rubber Lined and Covered Equipment

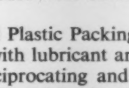

Sintered Metal Friction Elements


Asbestos Textiles



Industrial Adhesives


Teflon Tape, Packings, Sheets, Rods, Tubes


Engineered Molded Rubber and Plastics

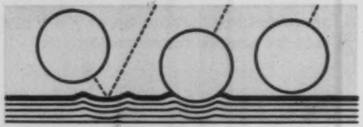
RM

CUT COSTS WITH

Crucible fatigue-resistant springs–

"MADE STRONGER TO LAST LONGER"

These Crucible coil springs offer far greater fatigue resistance than ordinary springs. They therefore cut replacement costs substantially.



Because the springs are stronger, they can carry greater loads, too.

The reason why these springs have higher strength and last longer is due to the fact that they're *shot peened*—

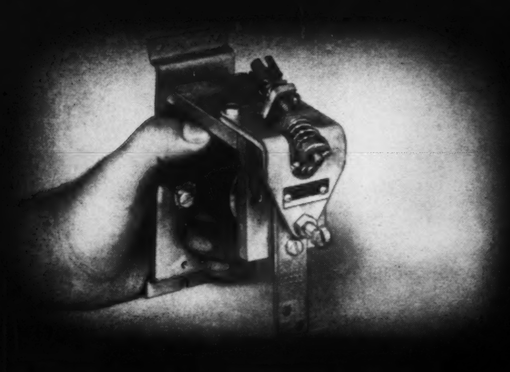
Shot peening imposes a compressive stress on the surface that offsets stresses set up in service. It also conditions the surface. And it eliminates minute stress concentration points which could lead to premature failure in a conventional spring.

Shot peening, together with Crucible metallurgical skill (from ore to finished spring), ensures springs that withstand high stresses longer. Hot-wound, *fatigue-resistant* springs are available in a wide variety of sizes, analyses and treatments to meet your compression, tension, and torsion spring requirements.

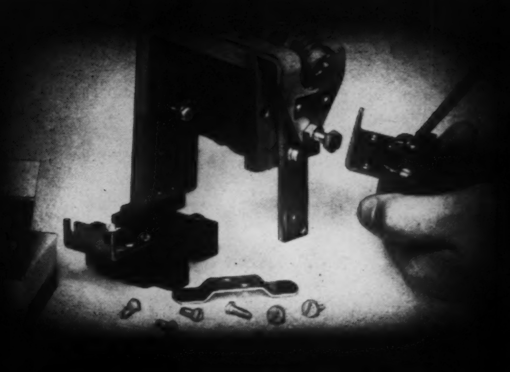
For more information on cutting costs with springs, send for a free copy of Crucible's "Coil Spring Design" handbook. Or have a Crucible spring specialist call on you. Write: *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE **HEAVY-DUTY COIL SPRINGS**

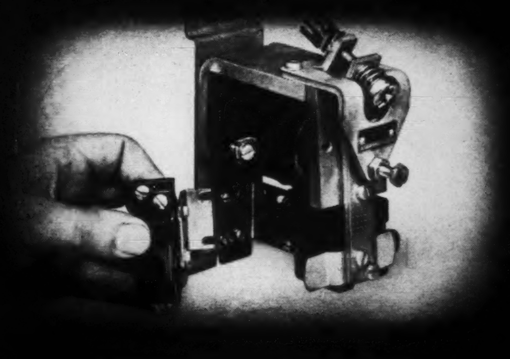
Circle 428 on Page 19



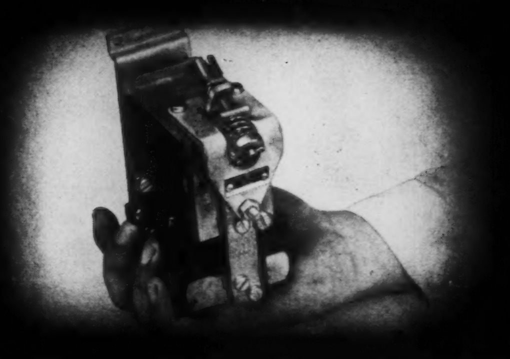
Unit-mounted frame and coil part . . .



with hardware assembly kits . . .



and "universal" contact blocks . . .



permits assembly of more than 100 devices

GENERAL ELECTRIC ANNOUNCES

NEW "building-block" d-c contactors and relays

General Electric's new line of d-c contactors and relays features a new concept in component design—building-block construction. Using front-connected frame and coil parts, standard assembly kits, and "universal" contact blocks, more than 100 different control devices can be assembled. This new design concept makes possible these important cost-saving advantages:

Reduced inventory—with building-block design, you need to stock only a minimum number of standard parts. Not only does this mean less costly inventory, but valuable storage space can be released!

Immediate availibility—with General Electric devices, the contactor or relay you want can be assembled on the spot! No need to order a specific device and await delivery, or stock a large number of special ratings. Assemble what you want—when you want it!

Order today from General Electric's complete line of stock d-c contactors and relays featuring the new building-block construction.

NEED OTHER COMPONENTS?

General Electric also has complete lines of plate rheostats and vitreous-enameled resistors for all your control needs. For more information, contact your General Electric Sales Representative or mail this coupon today! Industry Control Dept., Roanoke, Va.

GENERAL ELECTRIC

Circle 429 on Page 19

Vitreous-enameled resistors—1070 ohmic values from stock, fixed or slide-wire, 5 to 200 watts. Call your G-E representative.

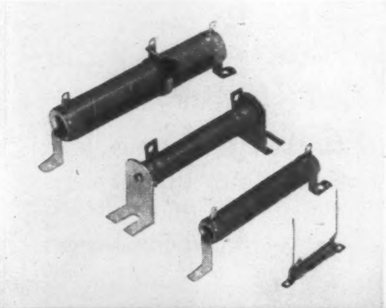
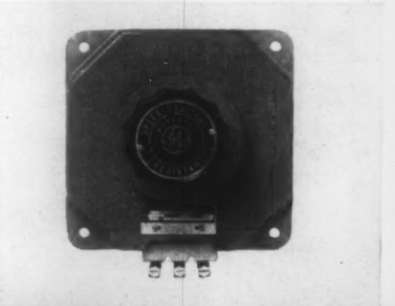


Plate-type rheostats—windings are completely encased in metal to give longer and more reliable service for any application.



To: Section B784-10
General Electric Co.
Schenectady 5, N. Y.

Please send the following bulletins:

☐ GEA-6621—D-c contactors and relays
☐ GEA-6592—Vitreous-enameled resistors
☐ GEA-6474—Plate-type field rheostats

Name________________________

Company________________________

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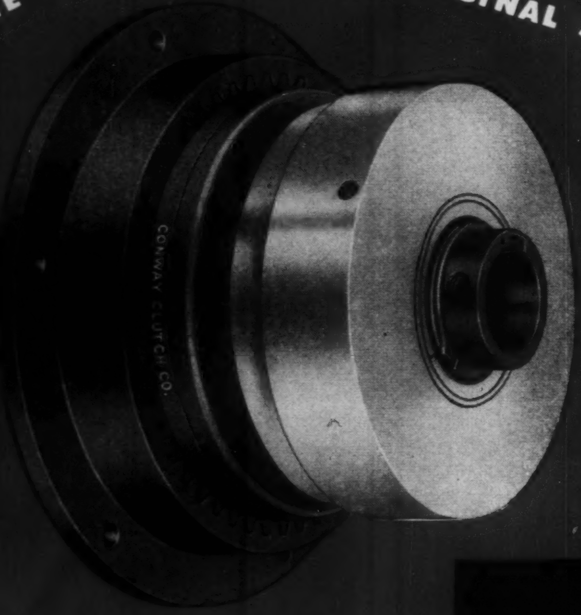
Announcing a revolutionary step forward . . .

Stationaire

by CONWAY

THE CLUTCH WITH THE ORIGINAL STATIONARY AIR HOUSING



successfully anticipates and satisfies the urgent demand by industry for economical power transmission by providing

POWER

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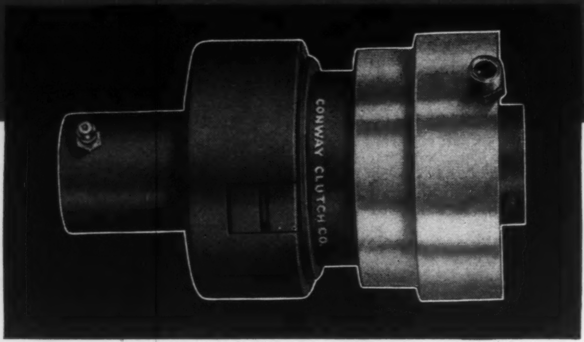
THROUGH AIR



Stationaire

offers all the better features of air clutches PLUS these exclusive Conway features:

Stationary air housing . . . no rotating union needed . . . no shaft drilling . . . mount anywhere along shaft . . . just slide on . . . can be used as double clutch . . . complete interchangeability . . . one-piece construction . . . available as couplings and many others.

● *WRITE FOR BULLETIN 858*

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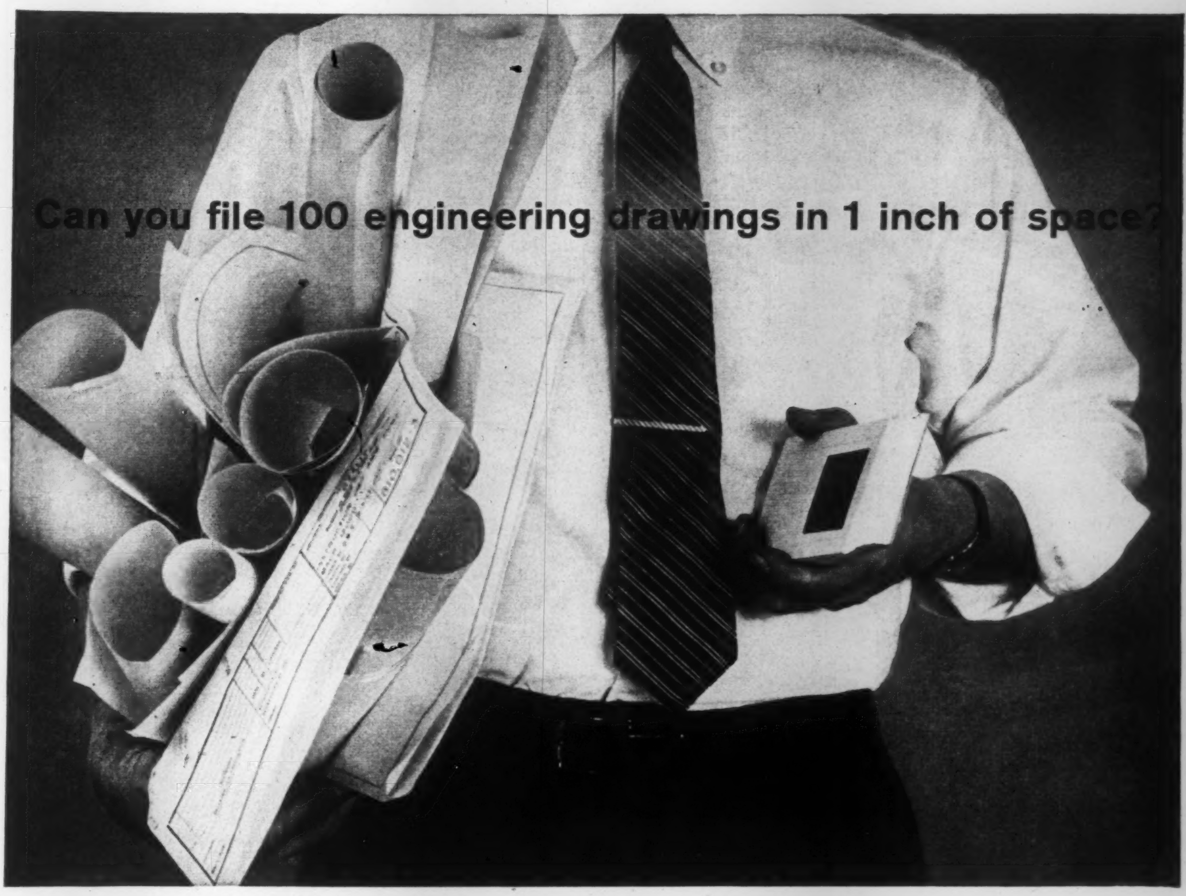
Pat. Applied-for U.S.A. and Canada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Microline in Canada, The Hughes-Owens Company, Limited, Montreal.

MICROLINE DIVISION OF OZALID
DEPT. S-9-4, JOHNSON CITY, N. Y.

Please send me the name and location of my local Microline Service Center. Also, the booklet giving the complete Microline story and containing a free demonstration offer.

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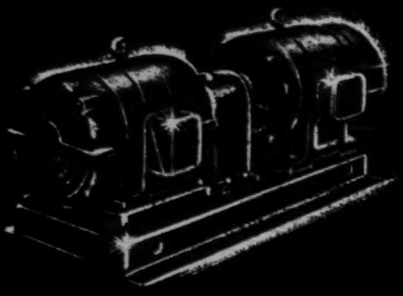
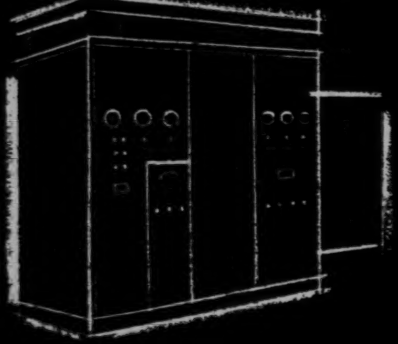
1 Precise high-frequency drives for generators or converters



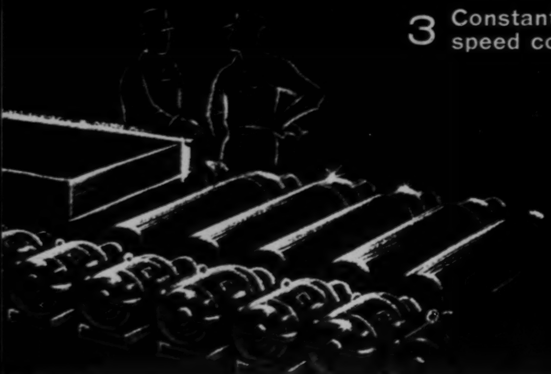
Because of its exact speed characteristic, the Syncro-Spede is an ideal driver for high-frequency generator sets where precise frequency is a necessity. The elimination of slip provides exact frequency throughout the entire load range of the motor.

2 Precise timing, metering, and recording devices



Syncro-Spede delivers and maintains exact synchronous speed within rated capacity regardless of load or line voltage dips. Its design permits mechanical modifications to meet special needs. Since it eliminates error caused by speed fluctuations, this new Louis Allis motor is also ideal for memory drums and precision timing devices.

3 Constant single- or multi-speed conveyor drives

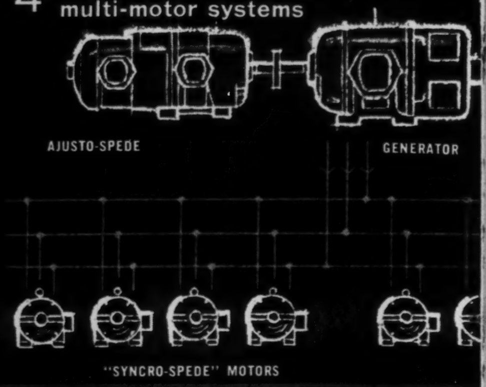


Syncro-Spede gearmotors can provide exact constant conveyor speed — or maintain correct relation of several conveyors operating at different speeds. Used with Louis Allis gear drives, the Syncro-Spede offers a practical, low-cost solution to low-speed conveyor drive requirements —down to 7.5 rpm.

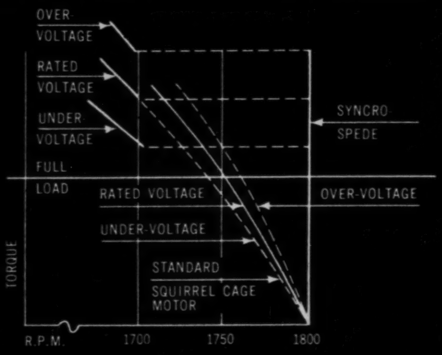
Below values are typical values based upon 100% pull-in torque with the external inertia equal to no more than twice the rotor inertia. To obtain full load and locked amps for other standard low voltages, multiply below 220 volt values by the inverse ratio of the voltages. For applications with high external inertias, refer to factory with specific inertia values.

HP	Synch. RPM	Frame Size	Full Load Amps 220 V.	% Locked Rotor Torque	Locked Amps 220 V.	Full Load Power Factor	Full Load Efficiency	Rotor WK²
1	1800 1200	182 184	4.4 4.6	275 200	30 30	59 58	76 75	.18 .22
1.5	1800 1200	184 184	6.6 7.0	265 200	41 41	59 58	76 75	.18 .24
2	1800 1200	184 213	7.7 8.3	250 200	58 58	64 62	82 78	.22 .49
3	1800 1200	213 215	11 14	250 200	83 83	67 61	82 78	.49 .80
5	1800 1200	215 254U	17 21	200 175	120 120	68 61	85 82	.80 1.30
7.5	1800 1200	254U 256U	25 28	200 175	170 170	68 62	86 83	1.30 1.80
10	1800 1200	256U 284U	34 36	200 175	240 240	68 63	85 83	1.80 3.50
15	1800 1200	284U 326U	49 54	200 165	330 330	70 63	86 84	3.0 5.50
20	1800 1200	286U 326U	63 65	200 150	420 420	70 64	87 85	5.00 5.50
25	1800	324U	79	200	520	70	87	6.0
30	1800	326U	95	200	700	70	88	7.0

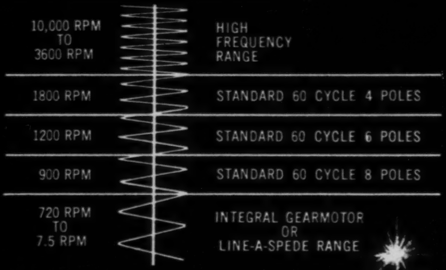
4 Adjustable frequency multi-motor systems

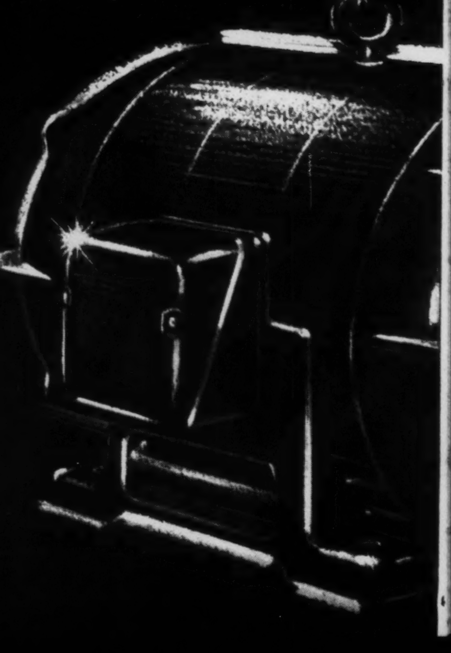


5 Any constant speed requirement



6 High speed — high frequency operation

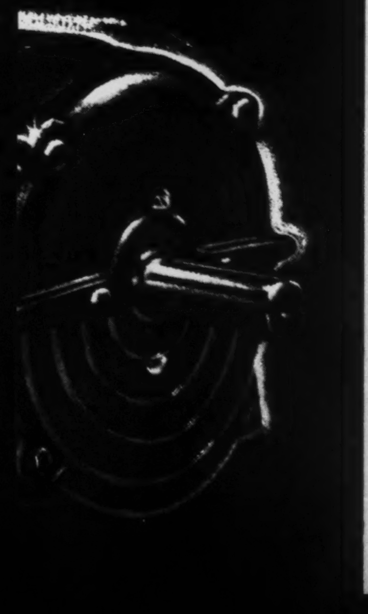

10,000 RPM TO 3600 RPM
HIGH FREQUENCY RANGE
1800 RPM
STANDARD 60 CYCLE 4 POLES
1200 RPM
STANDARD 60 CYCLE 6 POLES
900 RPM
STANDARD 60 CYCLE 8 POLES
720 RPM TO 7.5 RPM
INTEGRAL GEARMOTOR OR LINE-A-SPEDE RANGE



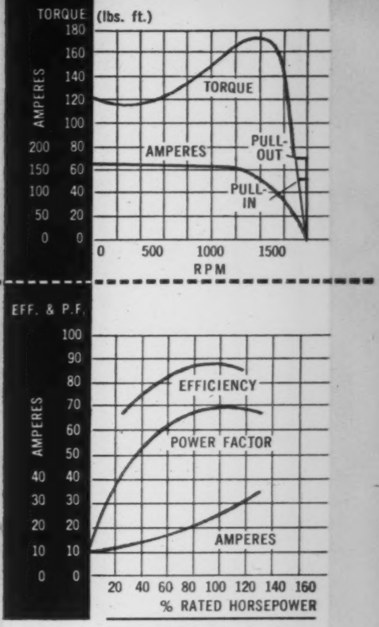
Syncro-Spede motors of different ratings and output speeds can be synchronized from a single adjustable frequency source — motors of various speeds will hold their exact relationship within an operating frequency range of 5 to 1,000 cycles. This combination provides precise adjustable frequency power for many applications in the printing, paper, plastic, and textile industries.

The Syncro-Spede offers virtually unlimited usage. It is much smaller than equivalent reluctance and DC excited synchronous motors—outperforms both and costs less. Under full load conditions, a standard squirrel cage induction motor may vary between 1740 and 1760 rpm with a 10% voltage variation — the Syncro-Spede maintains exact synchronous speed.

Syncro-Spede's indestructible cast aluminum rotor is designed for high-speed — high frequency operation. The small diameter rotor enables the motor to attain speeds previously impossible with other types of synchronous motors. With special rotor designs, the Syncro-Spede can reach speeds of 10,000 rpm and higher.



New-product news from Louis Allis



IMPROVED PERFORMANCE DATA

The Louis Allis Syncro-Spede

. . . a synchronous motor built in the same NEMA frames as standard motors of equal horsepower!

It's compact, simple, versatile . . . and trouble-free!

The remarkable Louis Allis Syncro-Spede® Motor enables you to provide exact synchronous speed for *any* application for less cost — with fewer controls — and in less space than previously possible.

If your equipment or operation calls for precise constant speed, check the advantages this new motor offers you:

Space-saving design — The revolutionary Syncro-Spede needs no external excitation, wound rotating fields, collector rings or brushes. It's built in the same standard NEMA frames as ordinary induction motors of equal horsepower. It requires less space — is virtually maintenance-free.

Wide range of enclosures — The Syncro-Spede can be provided in a wide variety of enclosures to meet special operating requirements. For example, Syncro-Spede is readily available in totally-enclosed fan-cooled and explosion proof enclosures — thus permitting installations which were difficult to make with D.C. excited synchronous motors.

Unmatched versatility — Syncro-Spede is available in standard sizes up to 100 hp, and even larger ratings for special applications. It can also be furnished in a wide range of mechanical modifications . . . base- or flange-mounted—as a gearmotor or brakemotor — even as a rolled-shell shaftless motor for "built-in" applications.

For full particulars and expert application engineering help, contact your local Louis Allis District Office. Or write for Bulletin No. 1900 to The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

Syncro-Spede is a Trademark of The Louis Allis Company

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

Circle 432 on Page 19

LA-240

Astrolite
Product
Bulletin

If ABLATION
combined with
High Temperature Insulation
is your problem....

ASTROLITE*

is your answer!

* The reinforcing fibers of ASTROLITE are Refrasil—consisting of continuous filaments of virtually pure silica.

REFRASIL IS IN LARGE SCALE PRODUCTION, IN A VARIETY OF PHYSICAL FORMS, TO MEET THE DEMANDS OF THE MISSILE INDUSTRY.

ASTROLITE resists up to 15,000° F for short duration uses!

If you are a Missile or Spacecraft Designer or Manufacturer—with a need for **ultra-high-temperature materials**, you know the vital importance of **low ABLATION rate.**

ASTROLITE is a remarkable **Refrasil**-reinforced plastic with impressive resistance to Ablation **and** extremely high temperatures—**up to 15,000°F.** for short-duration applications!

Fabrication techniques for ASTROLITE have been perfected to give optimum fiber orientation to resist Ablation—while retaining maximum insulation properties.

Many major airframe and missile manufacturers are using ASTROLITE today in their Space Technology programs.

Perhaps you can use ASTROLITE for insulation of Rocket Nozzles, Nose Cones, Deflector Vanes, Blast Tubes or Combustion Chamber Liners. Engineering counsel is yours for the asking. Please write to Director of Research.

ASTROLITE

Product Bulletin No. PB7-24 describes its astonishing resistance to ultra-high-temperatures. Write for it today.

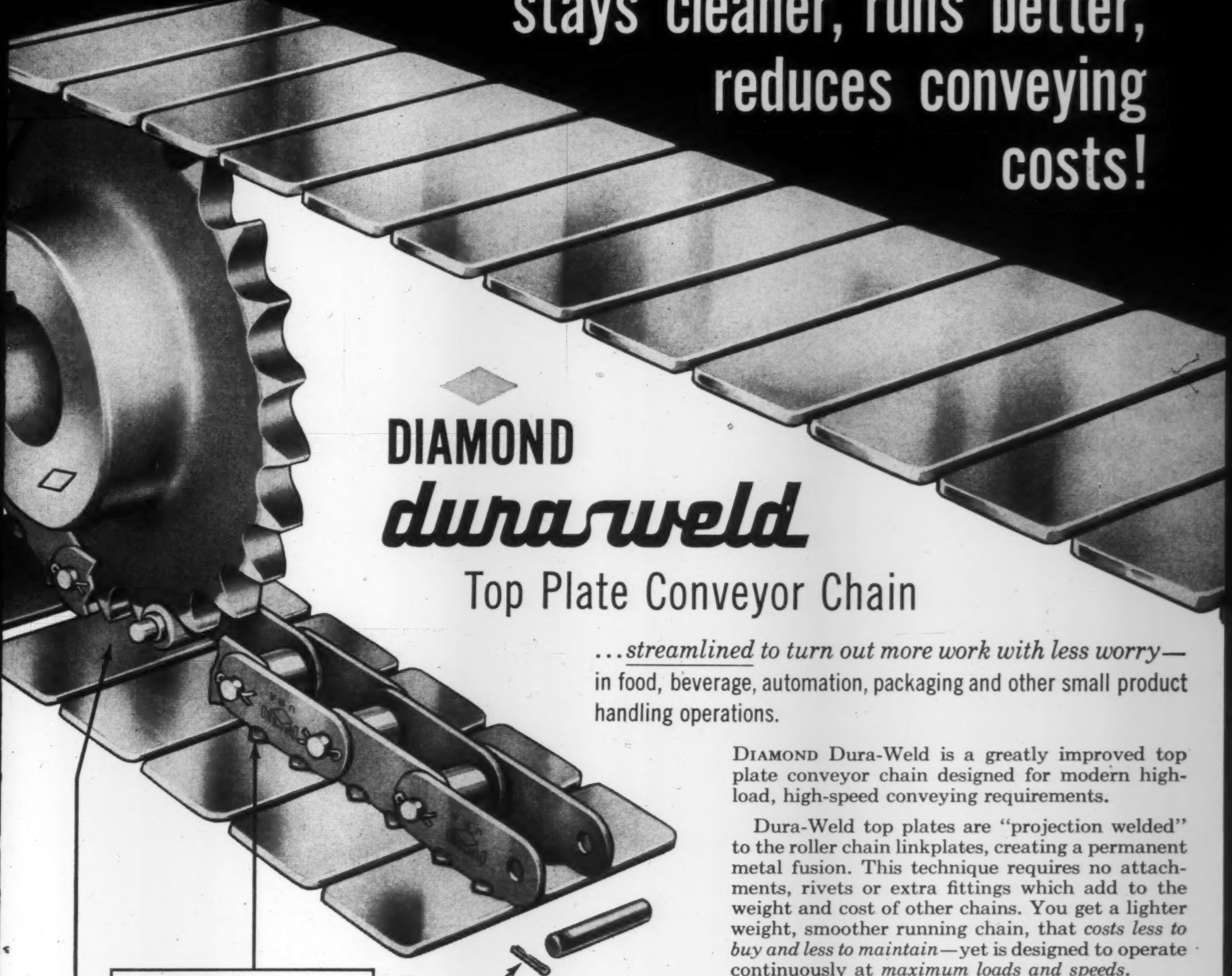
HITCO

H. I. THOMPSON FIBER GLASS CO.
1733 Cordova Street, Los Angeles 7, Calif. • REpublic 3-9161

Circle 433 on Page 19

WRITE OR CALL YOUR NEAREST HITCO REPRESENTATIVE: EASTERN: Tom Kimberly, 38 Crescent Circle, Cheshire, Connecticut, BRowning 2-6544; Fred W. Muhlenfeld, 6659 Loch Hill Rd., Baltimore 12, Md., VAlley 5-3135 • MIDWEST: Burnie L. Weddle, 1347 Pennsylvania St., Indianapolis 2, Ind., ME 5-5607 • SOUTHWEST: Marshall Morris, 2850A W. Berry, Rm. 14, Fort Worth, Texas, WAlnut 4-8679 • NORTHWEST: J. L. Larsen, 5757 Oaklawn Place, Seattle, Wash., PArkway 5-9311 • CANADIAN PLANT: THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston St., Guelph, Ontario, Telephone: TAylor 2-6630

new! "projection welded" conveyor chain stays cleaner, runs better, reduces conveying costs!



DIAMOND *dura-weld*

Top Plate Conveyor Chain

. . . streamlined to turn out more work with less worry— in food, beverage, automation, packaging and other small product handling operations.

DIAMOND "projection welds" produce a permanent metal fusion as strong as the metal itself. Permits cleaner streamlined design.

Dura-Weld's case hardened bushed joints and deep sprocket engagement assure smooth chain operation under maximum power, load and speed conditions.

Dura-Weld is easily detachable at any joint. Dura-Weld links may be attached to existing roller chain of the same general type and may be used on the same rails.

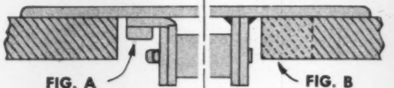


FIG. A FIG. B

DIAMOND Dura-Weld requires none of the attachments or rivets shown in Figure A. This permits a simplified design that is easier to keep clean, and gives up to 35% more rail load-bearing area. Permits use of wider supporting rails for greater distribution of load, Figure B.

Copyright 1958 Diamond Chain Co., U.S.A.

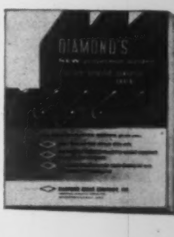
DIAMOND Dura-Weld is a greatly improved top plate conveyor chain designed for modern high-load, high-speed conveying requirements.

Dura-Weld top plates are "projection welded" to the roller chain linkplates, creating a permanent metal fusion. This technique requires no attachments, rivets or extra fittings which add to the weight and cost of other chains. You get a lighter weight, smoother running chain, that *costs less to buy and less to maintain*—yet is designed to operate continuously at *maximum loads and speeds.*

Dura-Weld gives you up to 35% more rail load-bearing area, permitting use of wider supporting rails. Because it has fewer parts to collect dirt it is easier to keep clean . . . and is less susceptible to shutdowns for repairs or maintenance.

Wherever flat top conveyors are used for intra-machine processing, bottling, capping, labeling, etc., you can cut costs and speed up production with new, streamlined, DIAMOND Dura-Weld Conveyor Chain. Write for full details, *today!*

Diamond Dura-Weld Conveyor Chain is now available from your Diamond Distributor's stock!



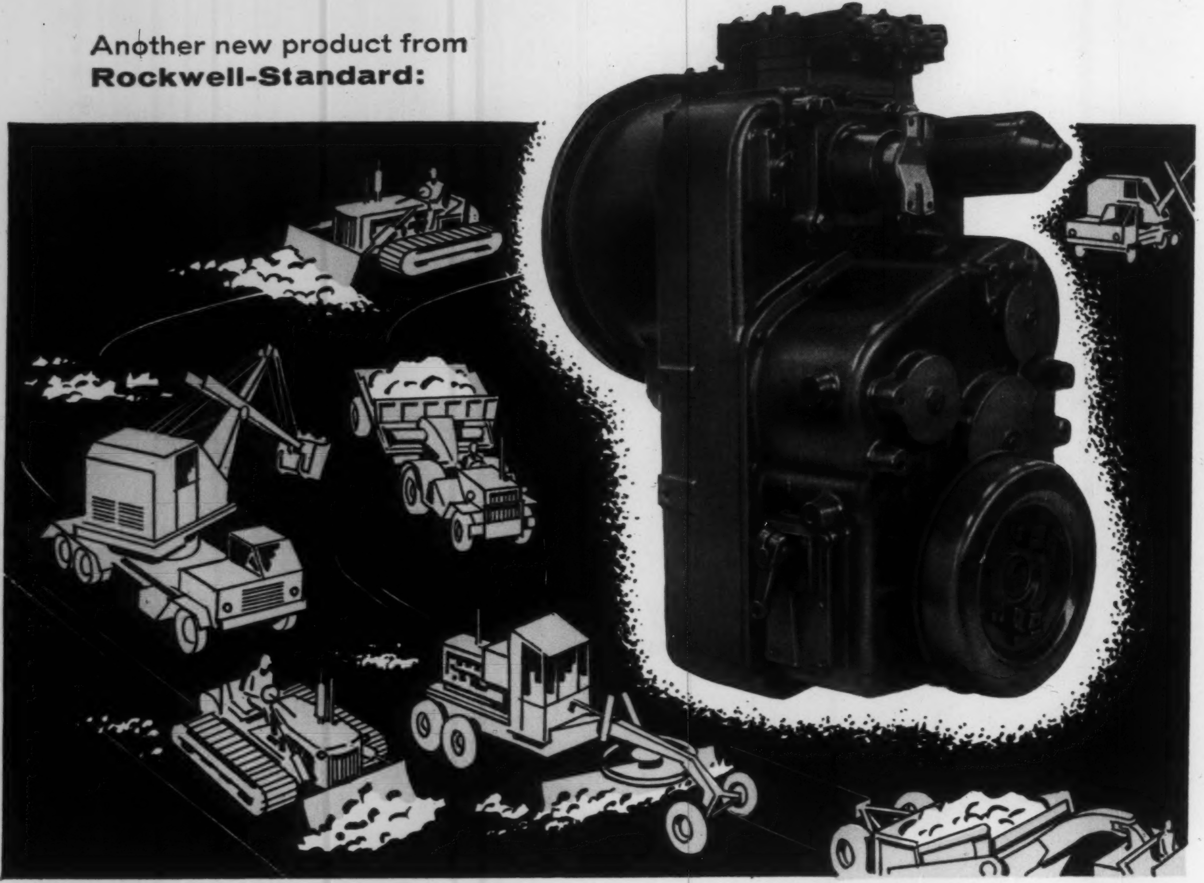
Write for FREE Folder!

Gives complete listing of DIAMOND Distributors and full description, specifications and prices of DIAMOND Dura-Weld Top Plate Conveyor Chain.

DIAMOND CHAIN COMPANY, INC.
A Subsidiary of American Steel Foundries
402 KENTUCKY AVENUE, INDIANAPOLIS 7, INDIANA
Offices and Distributors in All Principal Cities

Circle 434 on Page 19

Another new product from
Rockwell-Standard:



HYDRA-DRIVES®
POWER SHIFT TRANSMISSIONS

A torque converter...and 4 speed transmission in one compact package!

Hydra-Drives Power Shift Transmissions put *more* power to work . . . smoothly . . . efficiently . . . economically. Proved in hundreds of vehicles for three years, these units assure top work output of heavy-duty equipment. Engine lugging and heavy shock loads are eliminated. A 3 to 1 torque multiplication makes starting fast and effortless—even with heaviest loads.

Simple to operate, too, a flip of the operator's lever accomplishes power shifts within each range and without any interruption of the power flow. Automatic features of the converter and ease of power shifting simplifies operator training and lengthens vehicle life.

With four speeds forward and reverse, the Hydra-Drives Power Shift Transmission is ideally suited for vehicles which must travel in both directions during a normal work cycle. Rated at 550 ft. lbs. input torque, they can be used with a wide range of internal combustion engines up to 250 H. P.

The Transmission and Axle Division of Rockwell-Standard specializes in drive components only, and *does not compete with manufacturers of end products.* Take advantage of 50 years' experience in the manufacturing of power transmission components, specify Rockwell-Standard.

HYDRA DRIVES

ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

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Products of **ROCKWELL-STANDARD** Corporation

in
screw machine
products...

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Alcoa puts the metal where you want it

This shell for a Dyna-Empire, Inc. hearing aid button speaks loud and clear to *everybody* concerned with precision in screw machine parts. No larger than a penny, with walls only .006″ thick, machined to within .001″ tolerances, it proves just how precisely we put the metal where you want it.

Others tried to machine this "impossible" part. The scrap generation of 87 per cent and blistering heat in the thin sections licked them. Our solution: a special set of tools; a whopping knowledge of machining aluminum. And now these parts come shucking out at a tidy 300 per hour. The delicate pink anodized color and bright buffed finish on the outside show our skill in secondary operations at Lancaster, Pennsylvania.

In screw machine parts as well as forgings, castings, extrusions and impacts . . . Alcoa puts the metal where you want it. To you this may mean fewer rejects or ingenious design solutions . . . less waste in production or a product that sells faster. Start now; write for Alcoa's Up-to-Dater, a starter file of ideas and design tips on Alcoa Engineered Products. Aluminum Company of America, 951 Alcoa Building, Pittsburgh 19, Pennsylvania.

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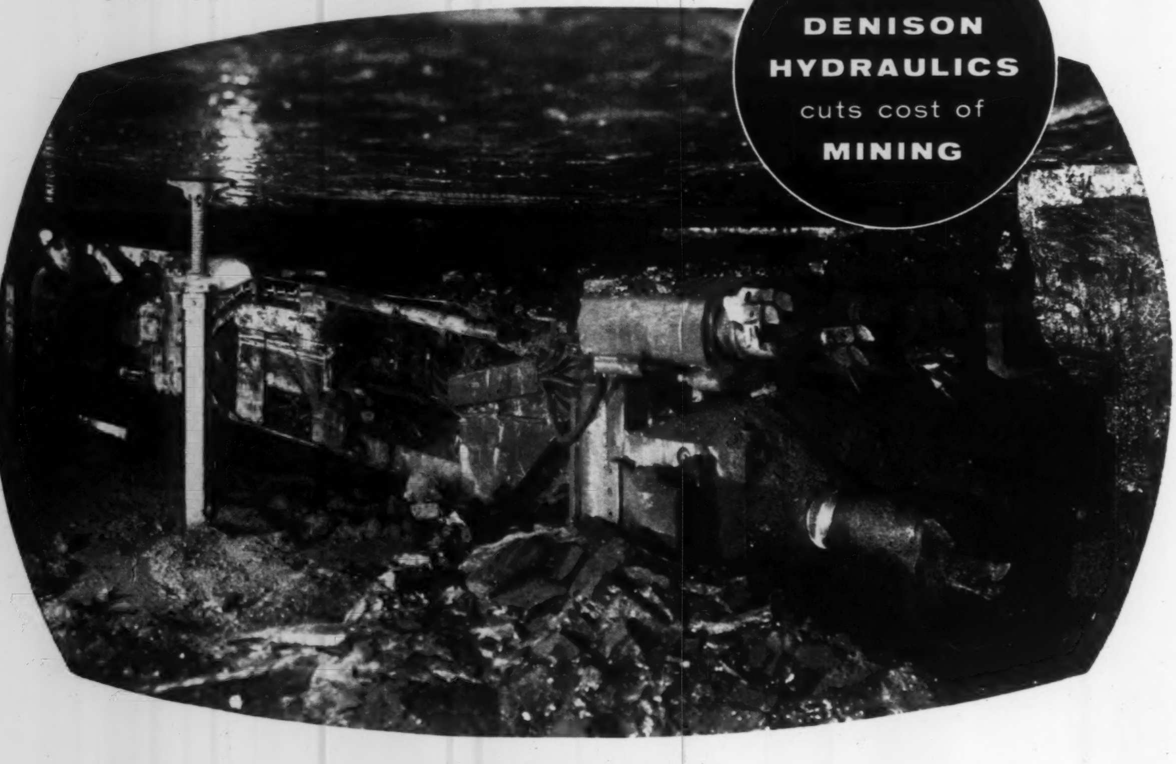
Alcoa puts the metal where you want it — in castings, forgings, impacts, extrusions and machined parts.

"ALCOA THEATRE"
FINE ENTERTAINMENT
ALTERNATE MONDAY EVENINGS

FAMOUS JEFFREY COLMOL®... continuous mining machine made by The Jeffrey Manufacturing Co., Columbus, Ohio—shown operating in 42" coal. Production: over 800 tons per shift. *Denison hydraulic equipment assures instant, dependable hydraulic power to help the Colmol mine faster, at less cost.*



How
DENISON
HYDRAULICS
cuts cost of
MINING

Instant-acting **DENISON** hydraulic power helps **JEFFREY** Colmol® devour over 800 tons per shift

TOUGH MINING doesn't stop Jeffrey's famous Colmol®. This powerful, compact continuous coal-mining machine works efficiently under the most severe operating conditions—producing over 800 tons per shift. *And the Colmol counts on dependable Denison hydraulic power for instant, accurate control that results in fast, low-cost mining.*

The Colmol's simplified, easily accessible hydraulic system includes a wide range of rugged Denison hydraulic equipment—four 2000 psi Vane-type Pumps... four Fluid Motors... plus flow controls, relief and check valves.

Three of the Vane Pumps power four Fluid Motors which drive the Colmol's two crawler treads, two discharge conveyor chains, and a swinging discharge conveyor chain.

The other Vane Pump operates 8 hydraulic cylinders which separate the Colmol's top and bottom head sections to adjust the breaker arms for working various coal seam heights... raise, lower and tilt the entire Colmol mining head.

Added advantages—Denison hydraulic power provides *infinite speed adjustment* for the Colmol. Simple hydraulic controls allow *one operator* to vary the machine's feed speed from zero to 46 inches per minute for mining... and from zero to 23 feet per minute for high or low-speed tramming in forward or reverse. This is *hydraulic flexibility that pays off* in today's modern mining operations.

It's another example of hardworking Denison hydraulic power doing jobs better... faster throughout industry. Your Denison Hydraulic Specialist can help with *your* next design problem. Write us for details.

HYDRAULIC DRIVE for the Colmol... begins with 4 Denison 2000 psi TMC Vane Pumps—shown assembled on gear case with electric motor attached. Three Vane Pumps power four Fluid Motors which drive crawler treads and conveyors. Remaining Vane Pump operates eight multi-purpose hydraulic cylinders.

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 **Dublin Road • Columbus 16, Ohio**

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HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

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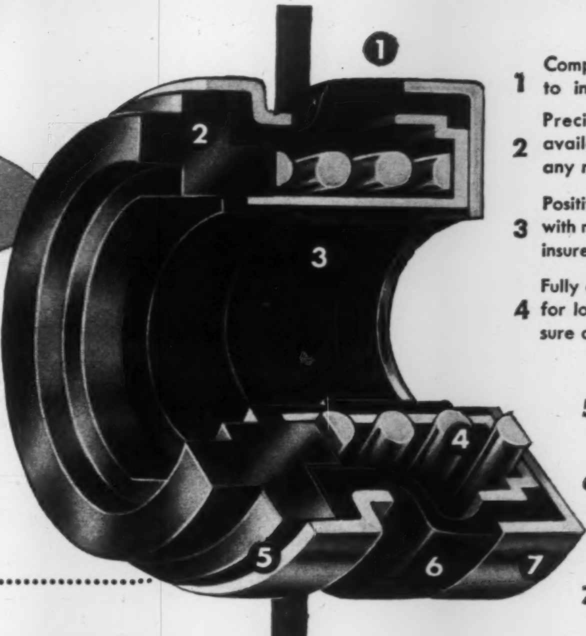
Circle 437 on Page 19

NEW Sealing Security for Rotating Shafts

VICTOR
VICTO-SEAL
AXIAL FACE SEALS



1 Compact, integrated unit—easy to install in factory or field.

2 Precision-lapped seal ring—available in carbon-graphite or any required material.

3 Positive, long-sleeve torque lock with mold bonded internal drive insures full-time rotating seal.

4 Fully enclosed, protected spring for long life and uniform pressure on seal ring.

5 Self-aligning seal ring—compensates for wear, shaft movement. Absorbs vibration.

6 Victoprene elastomer diaphragm highly durable under flexing.

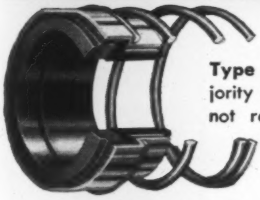
7 Heavy-duty metal ferrule on back of seal.

NEW TYPE 8...

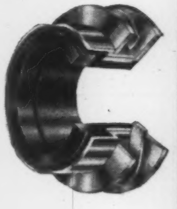
Heavy Duty

For ½- to 1-in. shaft diameter
For deep-well, shallow-well and domestic water pumps . . . centrifugal pumps . . . household appliances, etc.

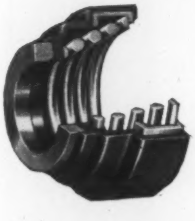
WIDE VARIETY OF VICTO-SEALS AVAILABLE



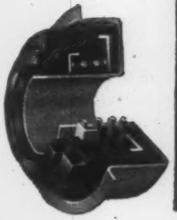
Type 2—Standard design for majority of applications where space is not restricted. Used on deep and shallow well water pumps, etc.



Type 2-S—Modified short-length version of Type 2 for restricted-area sealing such as on hydraulic pumps, refrigeration compressors, etc.



Type 6—Axial face seal with Victoprene O.D. Metal parts encased in Victoprene diaphragm to which seal ring is bonded. Application approved for household appliances.



Type 7—End face seal with metal O.D. and fully protected, rubber-enclosed spring. For automotive water pumps, etc.

Full-time sealing assured with positive torque lock . . . no diaphragm fatigue

Type 8 is a highly developed, heavy-duty rotating shaft seal. Its patented torque lock with extended shaft contact mounting insures constant unitary function. It eliminates diaphragm fatigue and, together with high-quality compression spring, maintains effective sealing action at all times.

Note how the spring in Type 8 is fully enclosed—free from exposure to effects of fluid handled. This means added spring life and uniform pressure on the seal ring.

The diaphragm is a Victoprene elastomer, especially compounded to meet rigid operating specifications.

Seal ring mounting permits square self-alignment of face with mating surface. It automatically compensates for wear and shaft movement, absorbs vibration.

Write for Victo-Seal Literature

Moderately priced, the compact Type 8 Victo-Seal is readily adapted to your pump and appliance designs, and industrial equipment. Complete data on Type 8 and other types available through your Victor Field Engineer or from the factory.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

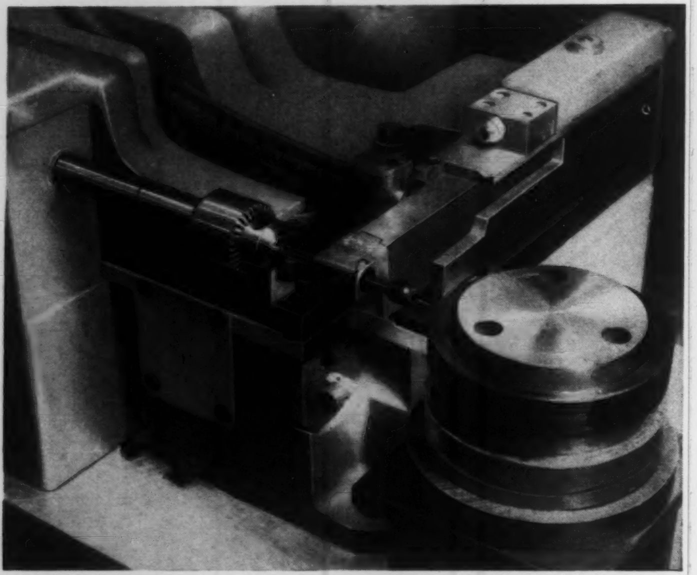
VICTOR
Sealing Products *Exclusively*

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

Circle 438 on Page 19

High Torque UNBRAKO socket set screws

Up to 40% higher tightening torques keep them tight whether installed by hand or power tools



NEW SPS SETOMATIC® automates socket set screw driving, will install set screws with any type point to full recommended tightening torque at rates as high as 2500 an hour. It can be set up for fully automatic operation, semiautomatic operation or manual operation. One manufacturer realized a 50% drop in installation costs, a 100% increase in production of finished assemblies.

RECOMMENDED SOCKET SET SCREW TIGHTENING TORQUES (in.-lb.)

Screw Size	Unbrako	Set Screw B	Set Screw C	Minimum Differential %
#4	5	3.9	3.5	28
#5	9	7.8	7.4	15
#6	9	7.8	7.4	15
#8	20	14.7	14.5	36
#10	33	26.5	25	25
¼	87	62	60	40
5/16	165	122	125	32
3/8	290	198	225	29
7/16	430	309	350	23
½	620	460	500	24
5/8	1225	1106	1060	11
¾	2125	1540	1800	18
7/8	5000	3660	4600	9
1	7000	5025	6500	8

The High Torque UNBRAKO is made to withstand the highest tightening torques ever used to seat a set screw—up to 40% higher than that of an ordinary socket set screw. And whether you drive them by hand or with automatic power tools, you can apply the force required to seat them without damaging the screw and be assured of full high-torque performance in every case.

Here's why a High Torque UNBRAKO can be seated tighter—and stay put

It has fully formed threads to make the whole screw stronger; a radius in the socket corners to prevent cracks from starting and to distribute the stresses developed in tightening; a deeper socket to give you more purchase with the wrench. It is properly heat treated, has uniform grain structure, is free of decarburization.

High Torque UNBRAKO socket set screws are stocked by authorized SPS distributors. Ask the one nearest you for complete details. Or write Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

hiRf
High Reliability factor

Research at SPS is realistic, for it faces the fact that industry is always seeking structural and mechanical components with ever increasing standards of predictable performance. By installing SPS high reliability fasteners in your assemblies, you increase overall product reliability.

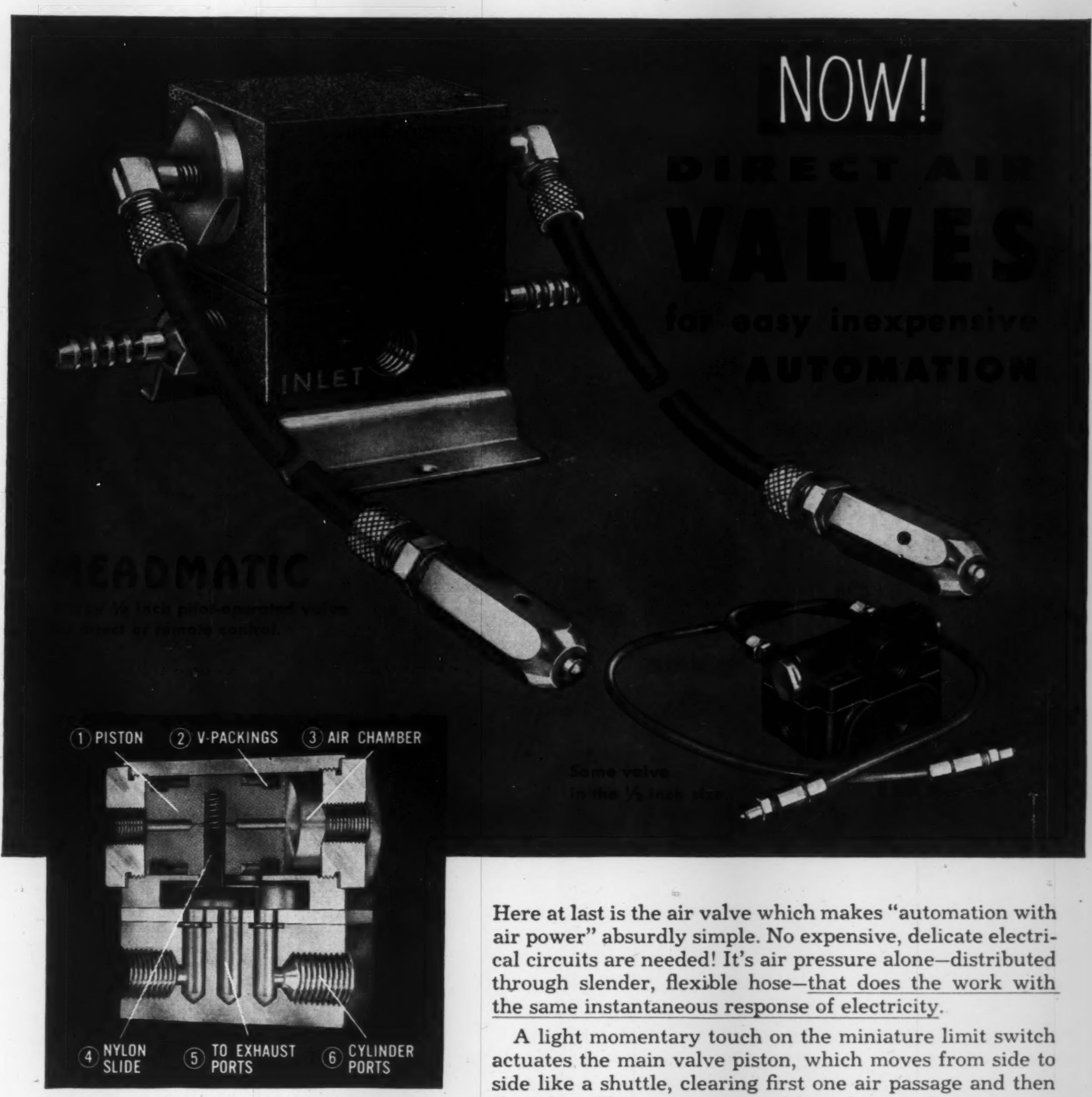
"High Reliability" is a booklet just published by SPS. Write for your copy today.

We also manufacture precision titanium fasteners / write for free booklet

SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. •
Columbia Steel Equipment Co. • National Machine Products Co.
• Nutt-Shel Co. • SPS Western • Standco Canada Ltd. •
Unbrako Socket Screw Co., Ltd.

Circle 439 on Page 19



NOW!

DIRECT AIR
VALVES
for easy inexpensive
AUTOMATION

MEADMATIC
new ⅛ inch pilot-operated valve
for direct or remote control.

Same valve
in the ½ inch size.

Diagram shows air flowing to one side of a double acting cylinder from outlet 6 while being exhausted through hole 5 on other side of cylinder. When the right poppet is touched, air is bled from chamber 3 and piston(1) is shifted to right. At this point, air is exhausted through port 6 as air enters opposite side of cylinder.

Here at last is the air valve which makes "automation with air power" absurdly simple. No expensive, delicate electrical circuits are needed! It's air pressure alone—distributed through slender, flexible hose—that does the work with the same instantaneous response of electricity.

A light momentary touch on the miniature limit switch actuates the main valve piston, which moves from side to side like a shuttle, clearing first one air passage and then the other. The piston is moved by releasing the air on one side through the limit switch. Regardless of amount of air pressure, a featherweight touch releases air, shifts piston.

The limit valves can be mounted at points where they will be tripped by the moving parts of a working machine, such as the ram of an air cylinder, the moving table of a milling machine, the depth stop rod of a drill press, or a revolving cam on a shaft.

Cost-saving possibilities are almost unlimited! Now clean, quick, dexterous air power can be directly integrated with mechanical functions of many production machines. New worlds open to original equipment manufacturers!

Let us help with your problem. If you have a possible application for **MEADMATIC** valves, timers or cylinders, tell us (confidentially) and we'll try to come up with the answer. Write for Air Power Catalog!

Write today for Air Catalog!

MEAD
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4114 N. Knox Ave., Dept. MC-98, Chicago 41, Illinois

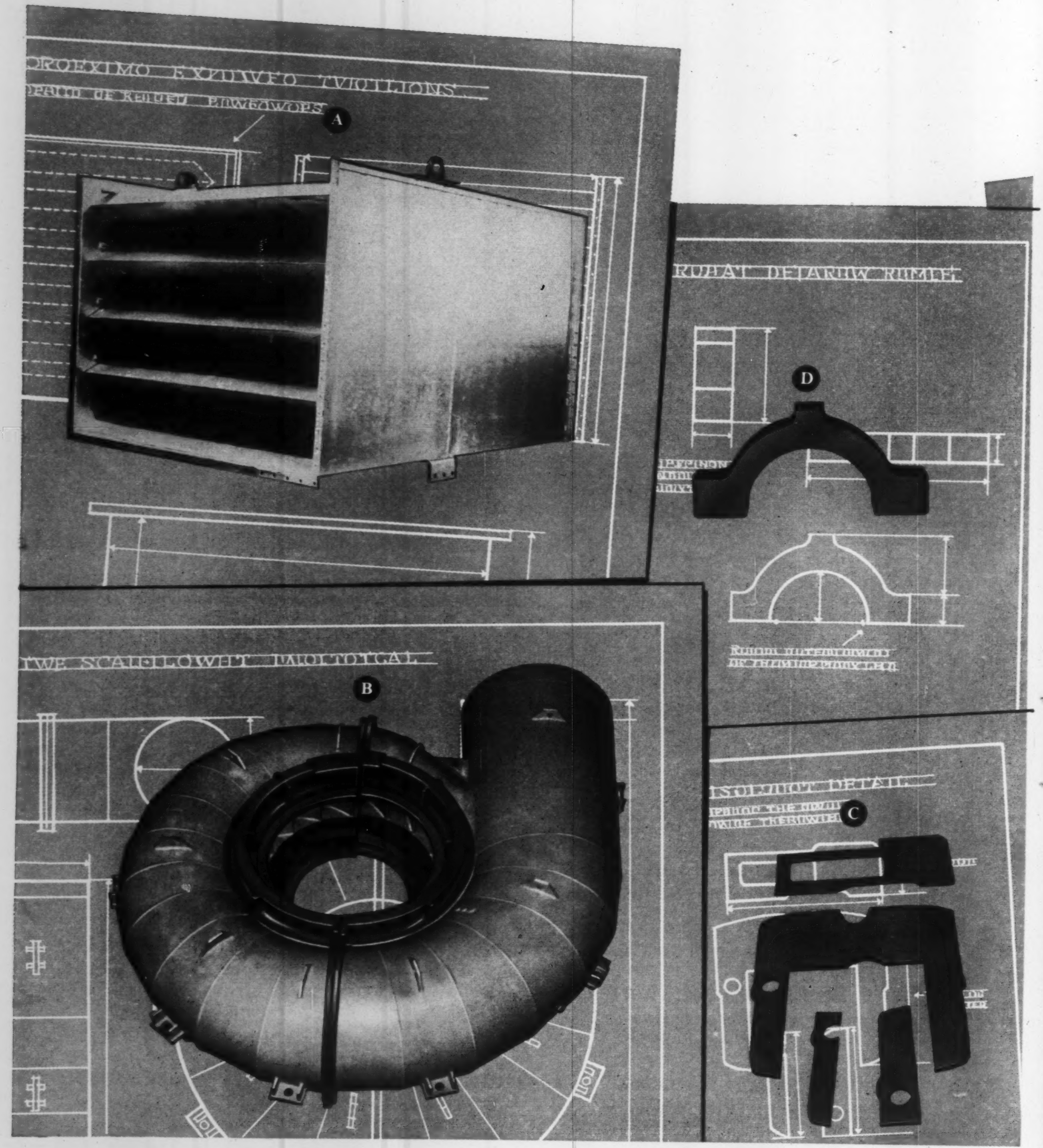
PATHFINDER IN AIR POWER AUTOMATION

IDEAS
THE MEAD MAN CAN HELP YOU CUT COSTS Now!

Circle 440 on Page 19

CLAYMONT Fabricated

complete assemblies or simple



Steel Plate Products . . .

parts—made to your specifications

Our modern, production-line Fabrication Shop is fully equipped and prepared to serve you by converting the steel plate of your choice into the parts or components you need.

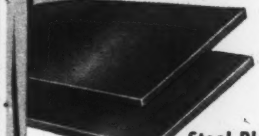
Getting exactly the right steel is no problem . . . Claymont makes its own. Every steel-production step is controlled within the company—from open hearth to finished fabrication. Top quality is assured. Your most exacting specifications are met or exceeded.

Small or large-quantity orders are handled with equal facility, and Claymont can offer quick-delivery service by water, rail or highway.

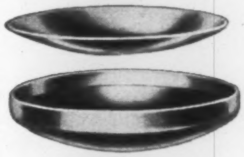
Use Claymont's complete facilities as a supplement or extension of your own. Contact our office nearest you for prompt, dependable assistance in solving your parts problems.

The products shown here are representative of the wide range of work Claymont's Fabrications Shop performs for its customers. Whether you need large, complex, fully-fabricated production weldments like a noise suppressor for turbines (A) or a scroll casing for hydroelectric installations (B)—or simple component parts like flame cut side and rear plate assemblies for fork lift trucks (C) or heavy gage steel bearing shells for marine turbines (D)—Claymont can fabricate them to your exact specifications. Claymont's 100,000 square foot facility includes a complete range of equipment for welding, pressing, shearing, flame-cutting, bending and machining.

OTHER CLAYMONT PRODUCTS

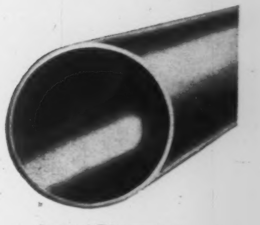


Steel Plates
Carbon • Alloy
Stainless-Clad • Nickel Plated
High Strength Low Alloy



Spun and Pressed Heads

Manhole Fittings and Covers



Large Diameter Welded Steel Pipe

CF&I

Claymont Steel Products

Products of Wickwire Spencer Steel Division • The Colorado Fuel and Iron Corporation
P.O. Box 1951 • Wilmington, Delaware

Albuquerque • Amarillo • Atlanta • Billings • Boise • Boston • Buffalo • Butte • Chicago • Denver • Detroit • El Paso
Ft. Worth • Houston • Kansas City • Lincoln • Los Angeles • New Orleans • New York • Oakland • Odessa • Oklahoma City
Philadelphia • Phoenix • Portland (Ore.) • Pueblo • Salt Lake City • San Francisco • San Leandro • Seattle • Spokane • Tulsa • Wichita
CF&I OFFICES IN CANADA: Montreal • Toronto   CANADIAN REPRESENTATIVES AT: Calgary • Edmonton • Vancouver • Winnipeg

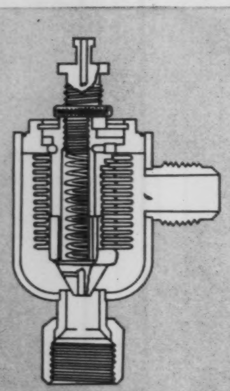
6155

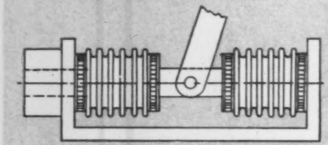
Circle 441 on Page 19

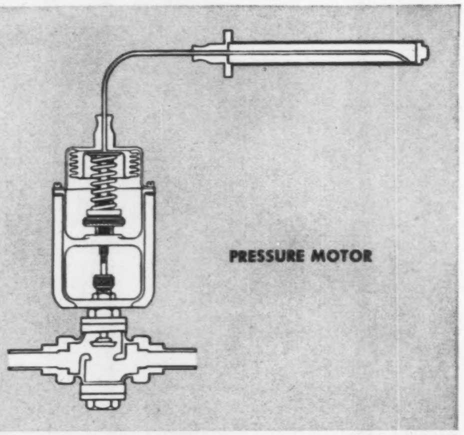
When your product must respond to temperature or pressure changes . . .

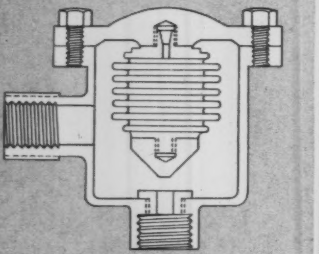
Specify Flexon Bellows

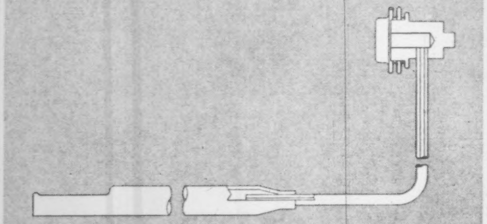
Cost-Engineered for Your Application

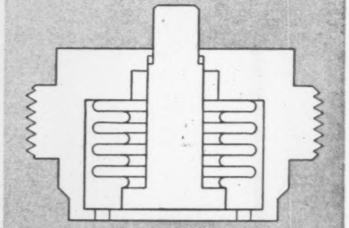

FLOW CONTROL

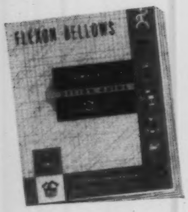

PRESSURE COMPENSATING DEVICES


PRESSURE MOTOR


VAPOR AND STEAM TRAPS


TEMPERATURE SENSITIVE DEVICES


PRESSURE SENSITIVE DEVICES



Ask for the Flexon Bellows Design Guide—20 pages of helpful application information.

While the importance of performance-engineering in bellows cannot be over emphasized, it is essential that cost-engineering be considered equally if your product is to compete in today's market. Bellows with specifications exceeding those required by your product may simply increase the cost. Specifying a special bellows where a standard can be used is another way in which costs may be increased unnecessarily. Flexonics Bellows Application Engineers are trained to evaluate your requirements with cost factors in mind. Go over your needs with them. For specific recommendations, send an outline of your requirements.

FLEXON

THE FIRST NAME IN MOTION CONTROL

B-53

9 plants to serve you in the United States and Canada

Flexonics Corporation

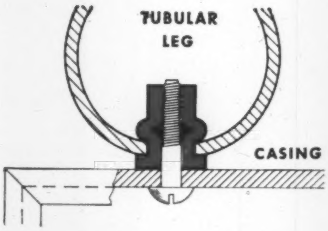
BELLOWS DIVISION

1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS

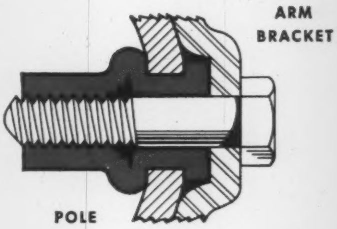
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

B.F.Goodrich

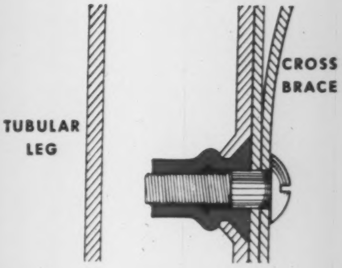
Only B. F. Goodrich Rivnuts® solve all these fastening problems so well


TUBULAR LEG
CASING

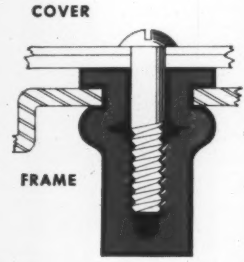
One man installs Rivnuts from one side in seconds—speeds assembly of *barbecues*. Permanent nutplates in legs save time in faster knockdown, too.


ARM BRACKET
POLE

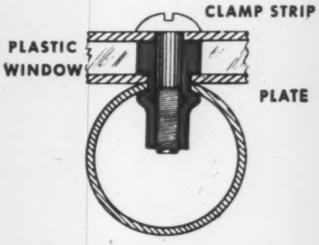
One man does the work of two, assembling arm brackets on *light poles*. Tests show pole or arm will fail before Rivnuts.


CROSS BRACE
TUBULAR LEG

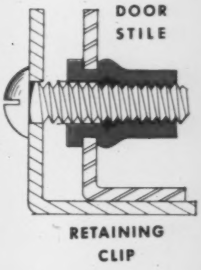
Clean, functional lines of modern *furniture* are preserved by Rivnuts. Upset inside tubular legs, they replace unsightly nuts, bolts and screws.


COVER
FRAME

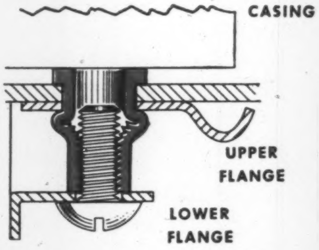
Rivnuts enable repair men to remove top of *automatic washer* and replace it easily. And Rivnuts can be installed after enamelling.


CLAMP STRIP
PLASTIC WINDOW
PLATE

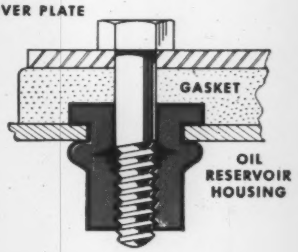
Upset Rivnuts secure *airplane window* plate to center post. Bulges in shanks seal out weather. Heads of Rivnuts serve as spacers for plastic window.


DOOR STILE
RETAINING CLIP

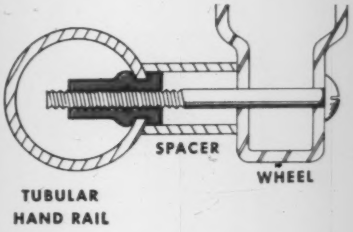
Rivnuts replace self-tapping screws used to hold retaining clips on aluminum *storm doors*, provide firm nutplates that won't loosen with shock or vibration.


CASING
UPPER FLANGE
LOWER FLANGE

Rivnuts eliminate need for reinforcing plates in *vaporizers*. In addition, Rivnuts space bottom flange automatically, prevent bending.


COVER PLATE
GASKET
OIL RESERVOIR HOUSING

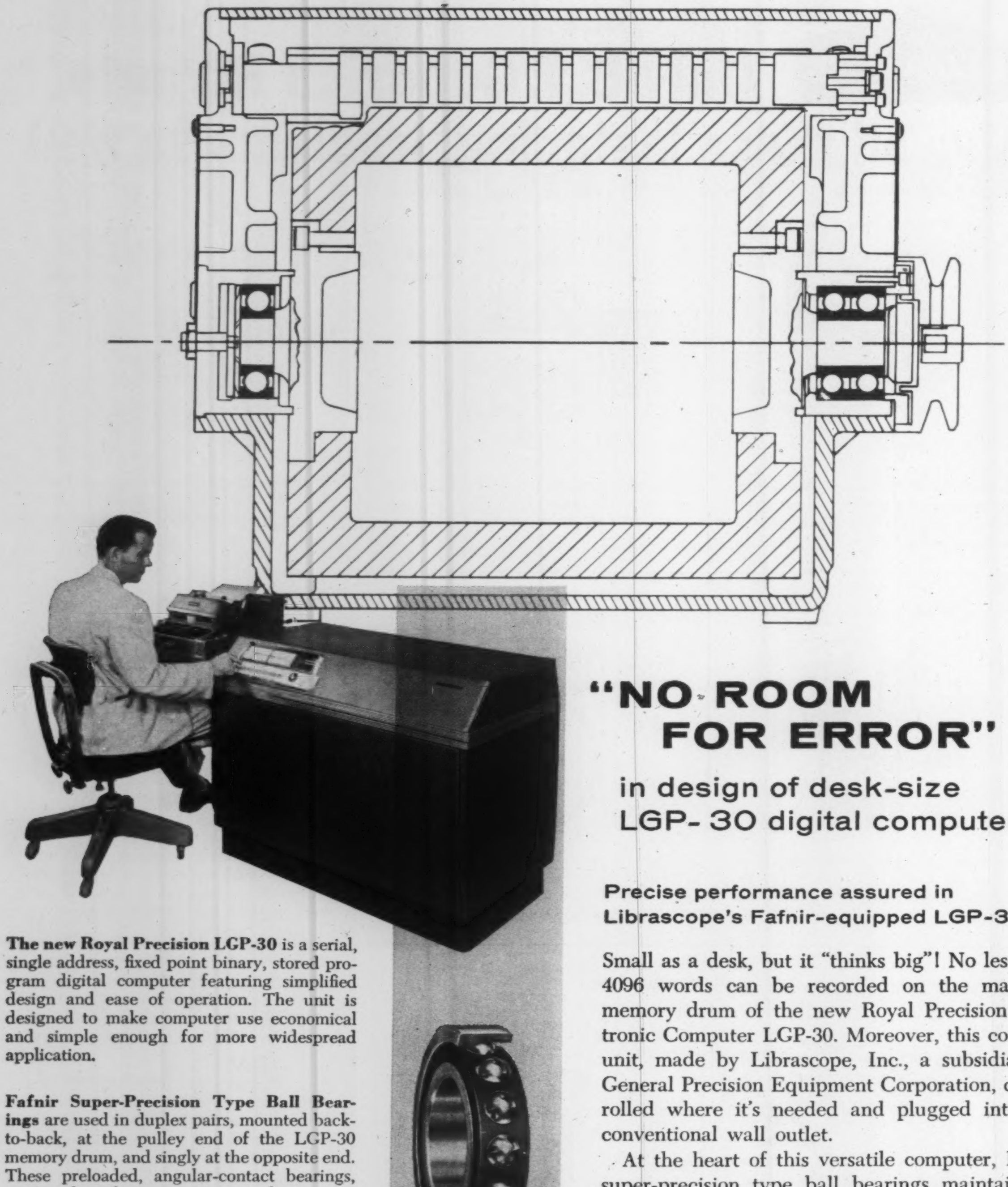
Assembly time for *oil reservoirs* is cut in half. Rivnuts eliminate welding, tapping and cleaning previously required to attach coverplate.


SPACER
WHEEL
TUBULAR HAND RAIL

Wheel chair designers needed a blind nutplate with at least 6 clean threads. Rivnuts, only one-piece blind rivets with threads, were the answer.

Special fastening problems? B. F. Goodrich Rivnuts solve them. Send for free demonstrator. Dept. MD-98.
B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Akron, Ohio.

B.F.Goodrich ***aviation products***



"NO ROOM FOR ERROR"

in design of desk-size LGP-30 digital computer!

The new Royal Precision LGP-30 is a serial, single address, fixed point binary, stored program digital computer featuring simplified design and ease of operation. The unit is designed to make computer use economical and simple enough for more widespread application.

Fafnir Super-Precision Type Ball Bearings are used in duplex pairs, mounted back-to-back, at the pulley end of the LGP-30 memory drum, and singly at the opposite end. These preloaded, angular-contact bearings, equipped with composition or bronze retainers, are widely used in precision-built mechanisms.

Precise performance assured in Librascope's Fafnir-equipped LGP-30

Small as a desk, but it "thinks big"! No less than 4096 words can be recorded on the magnetic memory drum of the new Royal Precision Electronic Computer LGP-30. Moreover, this compact unit, made by Librascope, Inc., a subsidiary of General Precision Equipment Corporation, can be rolled where it's needed and plugged into any conventional wall outlet.

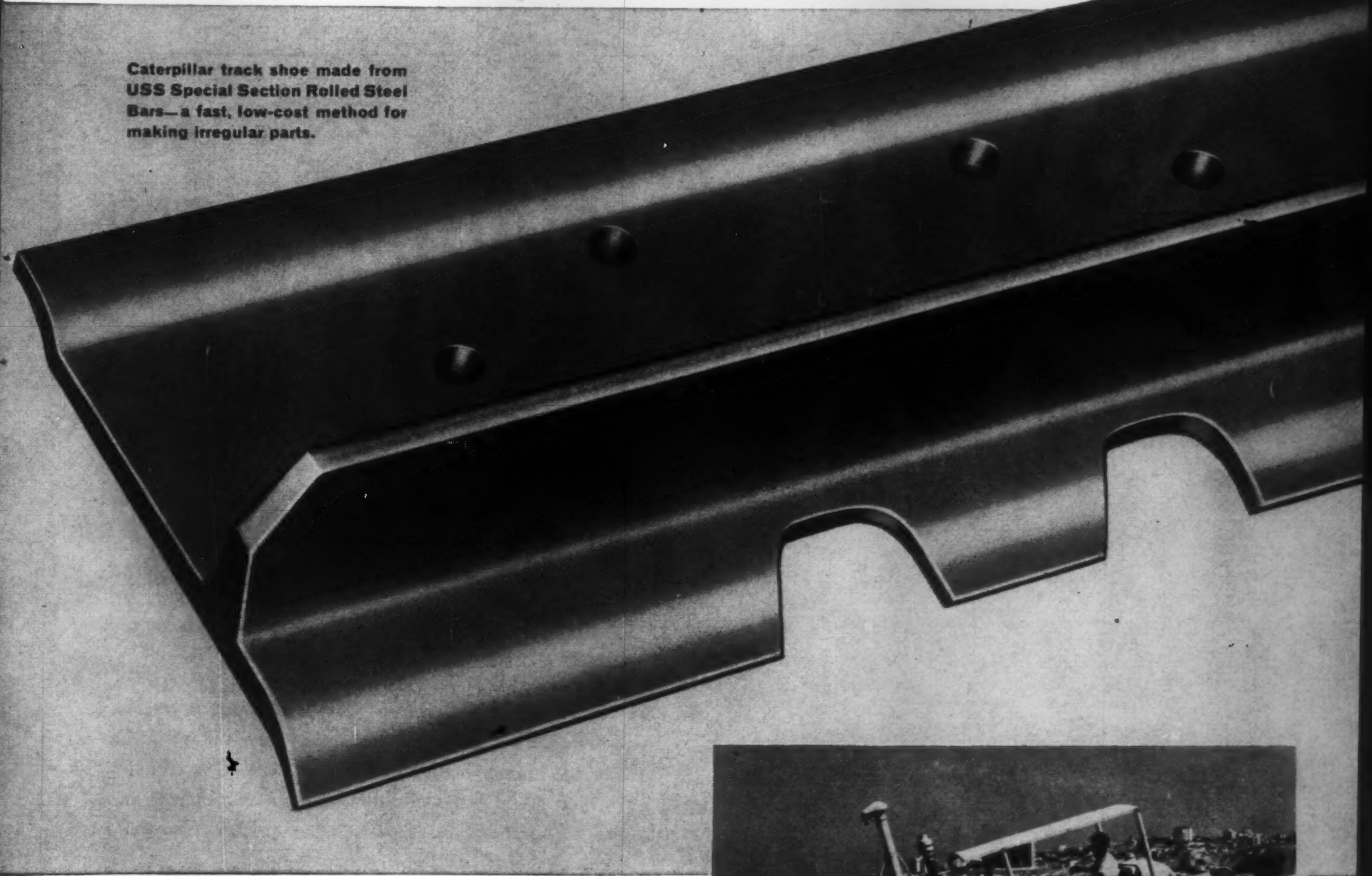
At the heart of this versatile computer, Fafnir super-precision type ball bearings maintain the precise alignment and high sensitivity required of the drum component. Counterbored to take a wide range of thrust, and radial loadings, these bearings provide the rigidity, extremely close-running accuracy, and low torque essential in this exacting application.

Fafnir's contribution to the development of the LGP-30 is another case history example of the high caliber and comprehensive scope of Fafnir design engineering services available to *you*. Take advantage of it when you have a bearing problem. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

Circle 444 on Page 19

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS



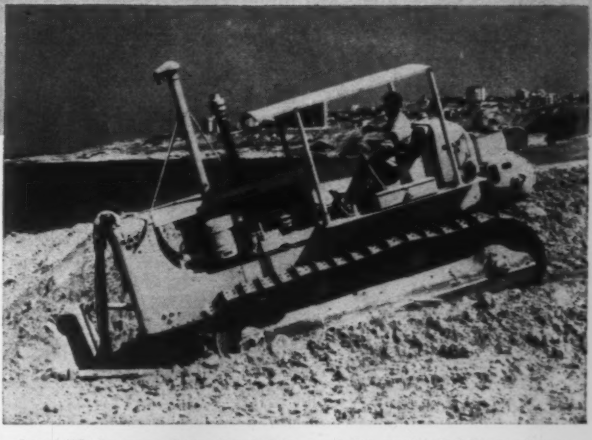
Caterpillar track shoe made from USS Special Section Rolled Steel Bars—a fast, low-cost method for making irregular parts.

Caterpillar makes this complex track shoe . . . from steel already rolled to shape!

The famous Caterpillar Crawler Tractors need a lot of shoes to make up their track—so the cost had to be kept low. To produce the highly irregular track shoe sections by machining, forging, casting or welding was either unsatisfactory, too costly or too slow.

They took the problem to U. S. Steel and a special section hot-rolled steel bar was suggested for the desired shape. The track shoes could then be sheared to the desired length. Three simple punching, shearing and drilling operations completed the job . . . and the shoes were ready for heat-treating and painting.

This method permitted more efficient production of track shoes, reduced the amount of steel needed, eliminated slow, costly machining, and cut scrap losses to rock bottom. The final shoe is strong, tough and long lasting.



Long life in rugged service has proved the quality of these shoes used in the endless track of Caterpillar Crawler Tractors.

Since 1928, Caterpillar track shoes have been produced by the thousands from USS Special Sections. No other production method has been devised that can compare with this for quality parts and low costs.

Why not get the facts on USS Special Sections? This is one way you can make substantial cost reductions and gain increased efficiency, too! United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

USS

United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Export Company

United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

"Cellulubes are against fire

**SAYS RICHARD A. PARKER, CHIEF ENGINEER
PARKER WHITE METAL COMPANY, ERIE, PENNA.**

"They also curtail corrosion . . . provide longer pump life and valve wear."

"In our hydraulic die-casting operation—involving open flame, temperatures to 1,400 degrees F, and molten metals—we consider it absolutely essential to use flame-resistant Cellulube for power transfer," continues Mr. Parker. "And with Cellulube we have no gummy valves, clogged strainers, or corroded reservoirs that characterized some of the fluids we formerly used."

This performance is typical of what you can expect from Celanese Cellulubes, which were developed to assure the safety of fire-resistance, with excellent lubricity and the dependability of unchanging operational viscosity. They are available in six controlled viscosities: 90, 150, 220, 300, 550, and 1,000 S.U.S. at 100°F.

Why not evaluate Cellulubes for your own operations? Just use the coupon to describe the application you have in mind and request technical data and samples.

Celanese® Cellulube®

**CELANESE CORPORATION OF AMERICA, CHEMICAL DIVISION
DEPT. 545-S, 180 MADISON AVENUE, NEW YORK 16, N.Y.**

Please send me:

☐ New Technical Bulletin "Celanese Safety Series" ☐ Sample, of_______viscosity.

Name & Title______________________________

Company______________________________

Address______________________________

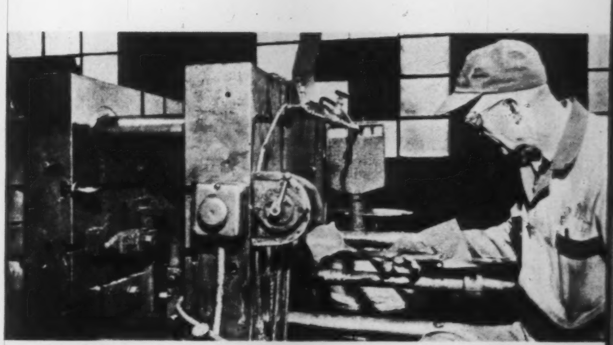
City_______________Zone______State__________

Application in mind______________________________

our insurance disaster"

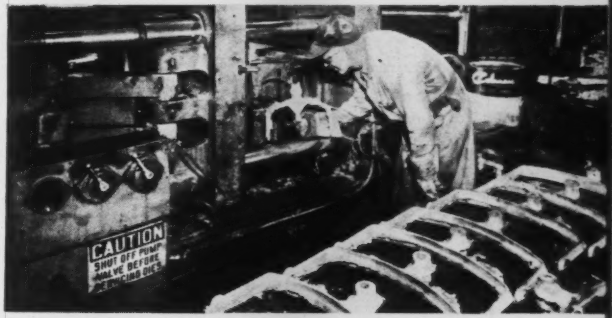
BETWEEN THIS . . .

Operator ladling molten metal into the shock chamber of 400-ton die casting machine. "Given the tremendous pressures under which the hydraulic fluid forces the ram home . . . we must prepare against a possible line rupture. It is vitally important that we use fire-resistant Cellulube in this operation."



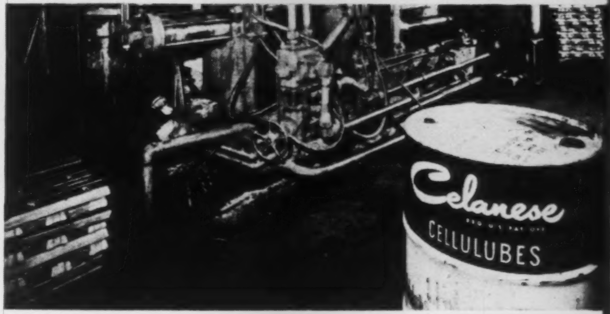
AND THIS . . .

Operator removing a casting from opened die. When the ramming operation is completed, the Cellulube is by-passed to the reservoir, ready for the next one. "Open flame coupled with leakage sometimes resulting from the tremendous pressures creates a serious hazard. Cellulube is our insurance against this hazard . . ."



. . . THIS!

Cellulube 150 is used in the Parker White Metal Company's 400- and 500-ton die-casting machines. Each machine uses 100 gallons of Cellulube. "Its performance has been completely satisfactory . . ." says Richard A. Parker, Chief Engineer.



FM
Factory Mutual-Approved
(Cellulubes 150 and 220)

Celanese
CHEMICALS

Celanese Corporation of America, Chemical Division, 180 Madison Avenue, New York 16, N.Y.
In Canada: Canadian Chemical Co., Limited, 2035 Guy Street, Montreal, P. Q., Canada.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, New York 16, N.Y.

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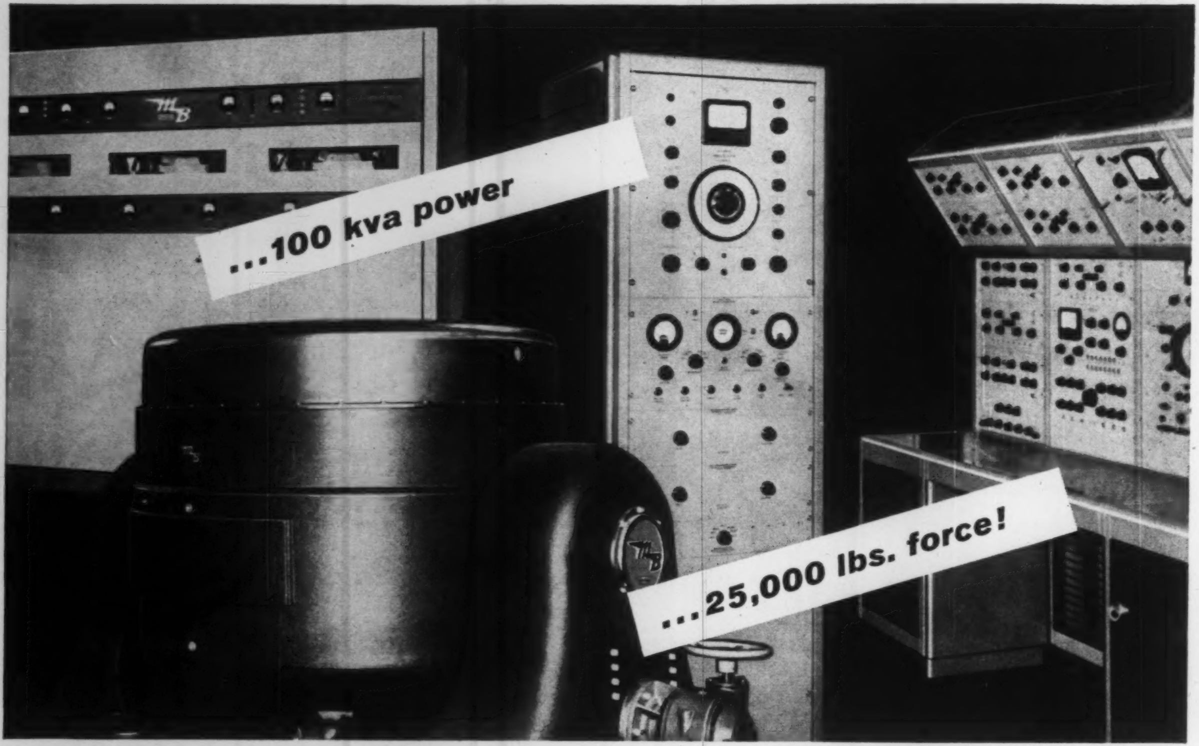
CELANESE CELLULUBES

MB develops largest vibration system!



THIS NEW, complete MB vibration test system is the largest in existence. It represents the most advanced equipment for high force, high frequency, high performance shake testing.

CONTINUOUS DUTY SHAKER: Featuring unique magnetic design, the MB C200 electrodynamic exciter delivers almost twice the force of its predecessor with but little increase in size. So efficient is this design, it reduces stray magnetic field at the table to under 20 gauss *without degaussing coil!* Unimode suspension (pat. pend.) of moving element permits full 1-inch linear table travel.

HIGH POWER AMPLIFIER: Rated at 100 kva continuous output, the MB-built T999 amplifier drives the shaker over its entire range under the most adverse reactive load conditions which are characteristic of electrodynamic exciters. It is designed by MB for optimum performance in both sine wave and complex motion testing, abounds with design advances and operating conveniences.

MATCHED CONTROLS: As part of the matched integrated MB system, the T68MC sine wave automatic cycling unit provides for remote control of amplifier, and contains all controls for running the shaker. The T88 complex motion console rounds out the system for the most exacting and advanced random motion testing.

UNDIVIDED RELIABILITY: Working with MB, you avail yourself of the longest experience in the field . . . the widest scope of test systems . . . the operational benefits of matched elements . . . the undivided responsibility for performance and service of the complete system . . . and the largest field service organization.

Send for Bulletin 470 which gives data on MB systems from 7000 to 25,000 pounds force. If you need less capacity, ask for Bulletin 435 (1750 to 5000 pounds force) or Bulletin 425 (1000 to 2500 pounds force).

largest producer of complete systems for vibration testing

MB manufacturing company
A Division of Textron Inc.

1056 State Street
New Haven 11, Conn.

Circle 446 on Page 19

ANNOUNCING

the cylinder you designed!

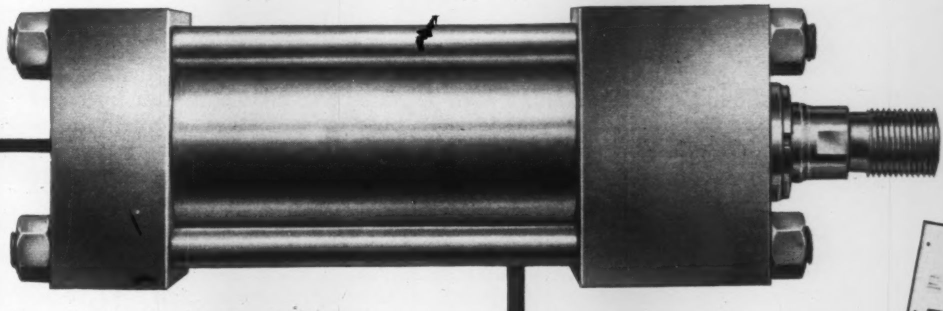
To save you and hundreds of other busy engineers time at the drawing board, Hanna representatives asked what you desired in hydraulic cylinder design.

You wanted a **stronger cylinder, preferably all steel with welded mountings.** You also wanted **tight sealing** at all pressures. These features were included in the Hanna Powrdraulic design. Some wanted **automotive piston rings;** others wanted **synthetic piston packings,** so the new flexible Powrdraulic design gives you a choice. You can also choose the **fast change cartridge gland** or the conventional **multiple lip packing** and you have a **choice of packing material** including Teflon* and silicone rubber.

Hydraulic cylinders should incorporate **industry standard mounting dimensions** and conform to Joint Industry Conference recommendations. These are included in the Powrdraulic design.

In addition, you want a cylinder that is **priced right,** with **prompt delivery** and **service available** in all parts of the country. You can have all this plus the assurance of quality when you specify Hanna Powrdraulic cylinders.

We will be happy to send you a catalog, and give you the name of your nearest Hanna Representative. You'll also find him listed in the yellow pages under "Cylinders" and in the alphabetical section of Thomas' Register.



Hanna Powrdraulic Hydraulic Cylinder
2000 psi and 3000 psi non shock — with generous factor of safety
Featuring — Pressure tightening tube seals
• One piece steel heads with welded mountings
• Double seal piston rings • Fast change cartridge gland
• Lubricated rod bearing

HANNA
Powrdraulic
HYDRAULIC
CYLINDERS

For full details write for Catalog 900

* Teflon is DuPont's registered trademark for its fluorocarbon resins.

Hanna Engineering Works

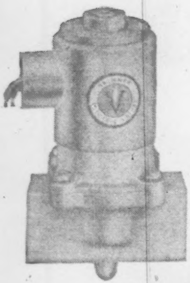
HYDRAULIC & PNEUMATIC EQUIPMENT • CYLINDERS • VALVES

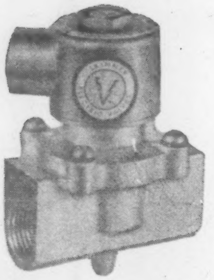
1765 ELSTON AVENUE • CHICAGO 22, ILLINOIS

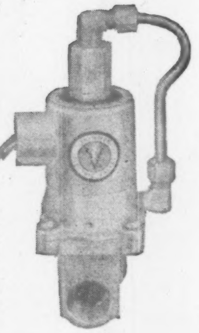
Circle 447 on Page 19

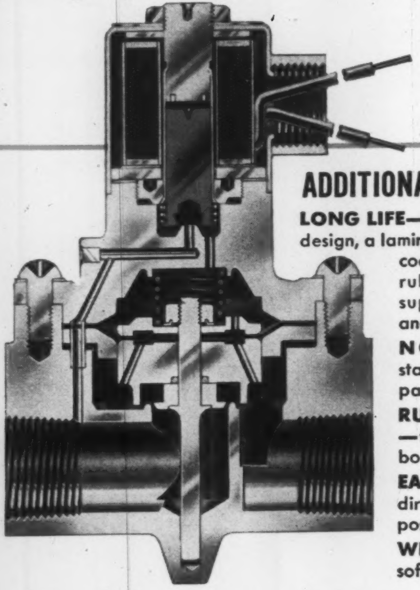
New low-cost, high-flow, 2-way valves with . . .

DEPENDABLE SKINNER QUALITY









ADDITIONAL FEATURES

LONG LIFE—unique diaphragm design, a laminate of nylon fabric coated with Buna N rubber, completely supported in open and closed positions.

NO RUSTING—stainless steel internal parts.

RUGGED DESIGN—forged naval brass body.

EASY TO MOUNT—direct to line in any position.

WILL NOT LEAK—soft, synthetic inserts.

L SERIES

These L Series valves with 3/4" and 1" diameter orifices complete an *all new* line of 2-way valves previously introduced in January in the 3/8" and 1/2" sizes.

Manufactured to the highest engineering standards, these pilot-operated, high-flow industrial valves are a welcome addition to the famous Skinner solenoid valve line. They are smaller and more compact than the M2 Series they replace and feature a unique diaphragm design. They are also considerably lower in cost. The 3/4" size, for example, will cost you 51% less.

These larger L Series models – 3/4" and 1" – will be available in standard and Explosion-proof construction, normally open or normally closed. They operate on a pressure differential of 5 to 150 psi and will control such common media as air, oil and water.

For complete information, please contact our Representative or Distributor near you . . . you'll find him listed in the yellow pages or write us at the address below, Department 429.

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN
CONNECTICUT
105 EDGEWOOD AVENUE

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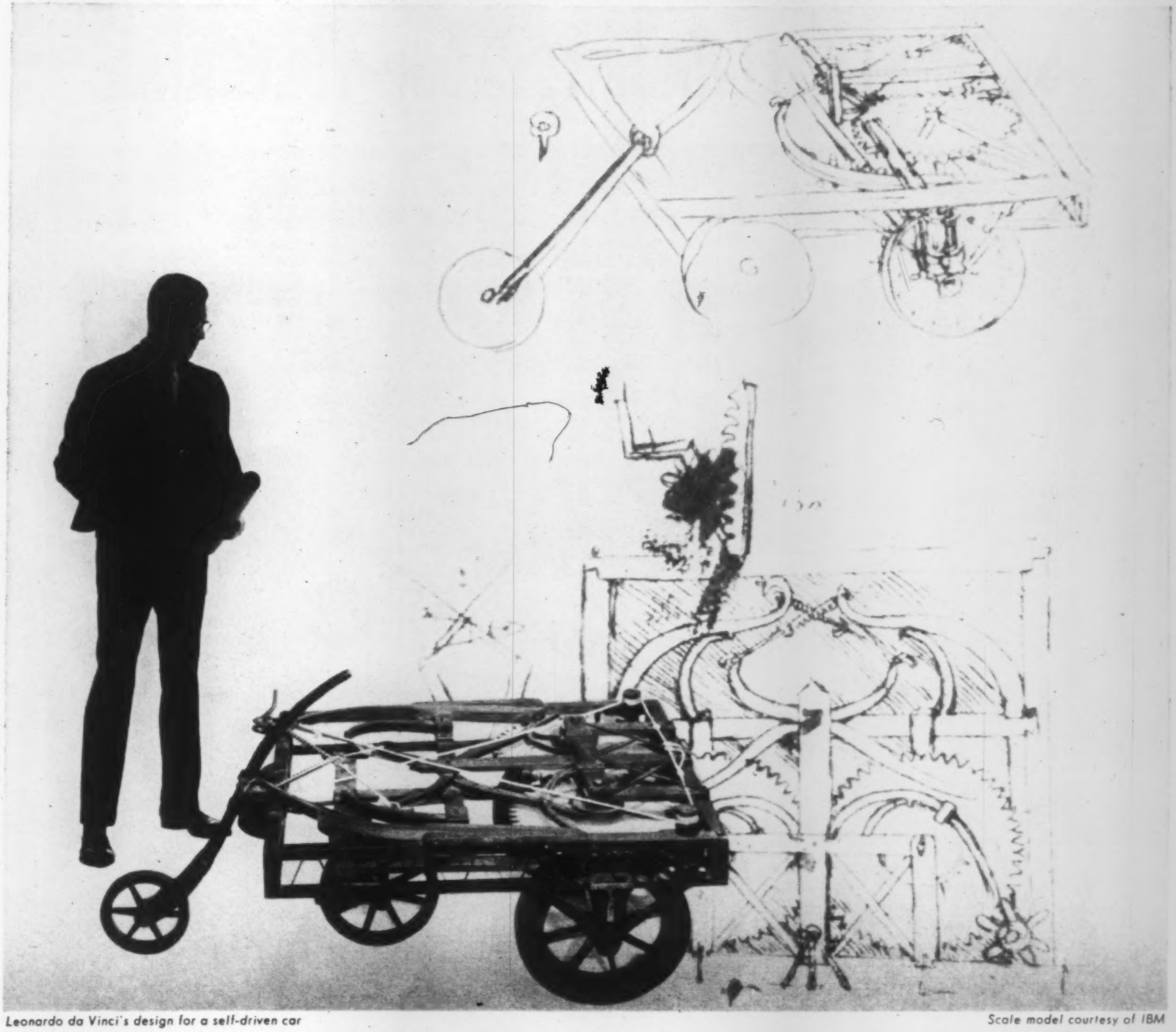
creative designing calls for an open mind



Leonardo da Vinci's design for a self-driven car

Scale model courtesy of IBM

EVEN DA VINCI'S SELF-DRIVEN CAR COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.

When you receive the recommendations of an SKF engineer, you know they are in no way determined by possible restrictions in his product line. That's because the SKF line includes all four types of ball and roller bearings, in many thousands of sizes. This gives every SKF engineer the kind of flexibility he needs to keep an entirely open mind on any bearing problem. Give us your problem and see. 7858

Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

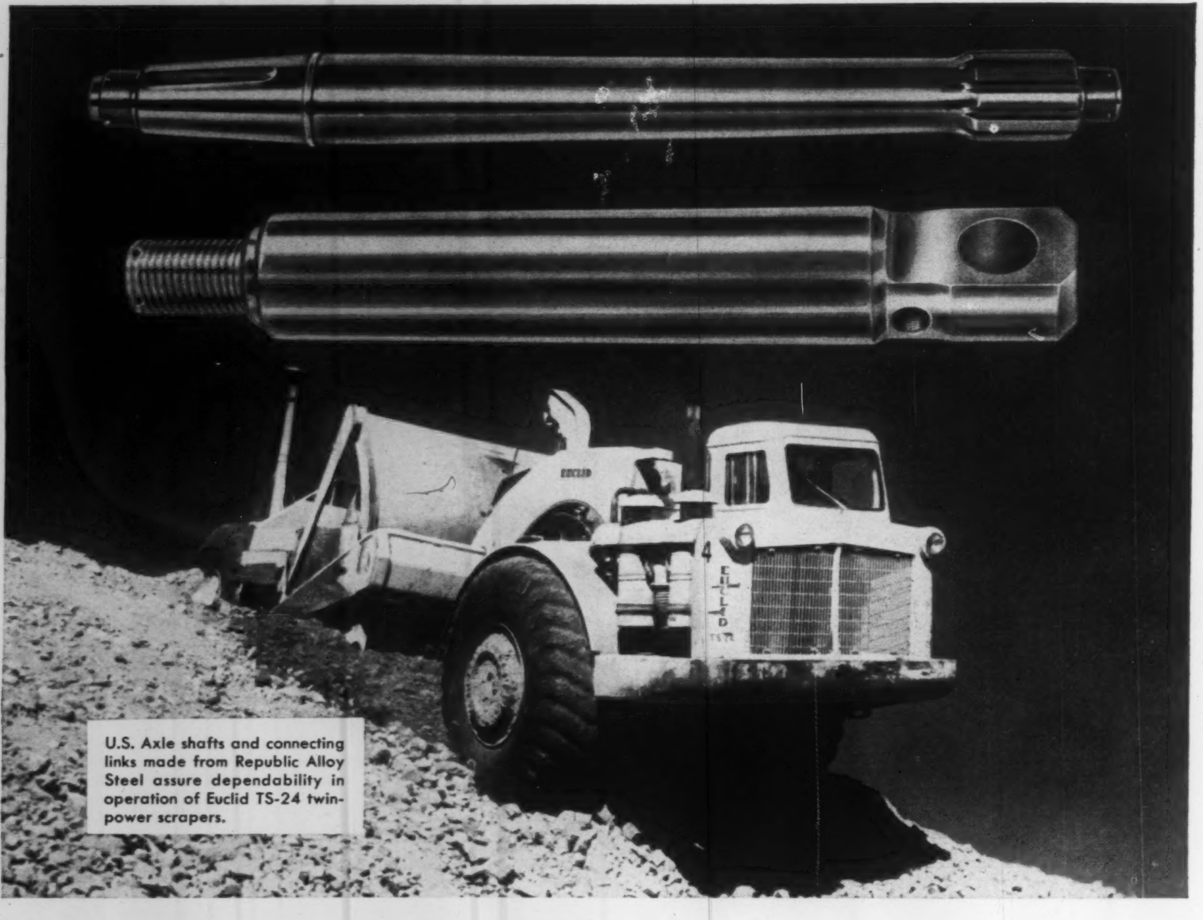
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

®REG. U. S. PAT. OFF.

Circle 449 on Page 19

Problem-Solving Products from Republic

MEET REQUIREMENTS FOR DEPENDABILITY, STRENGTH, ECONOMY, CLOSE TOLERANCE



U.S. Axle shafts and connecting links made from Republic Alloy Steel assure dependability in operation of Euclid TS-24 twin-power scrapers.

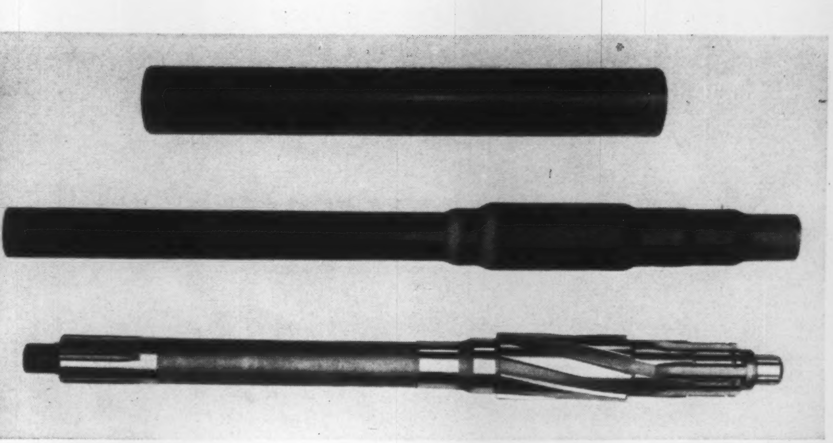
REPUBLIC ALLOY STEELS ADD DEPENDABILITY, TOUGHNESS, STRENGTH, QUALITY TO A PRESTIGE PRODUCT. Axle shafts and connecting links produced by The U.S. Axle Company, Inc., Pottstown, Pennsylvania, are known throughout the world for their extra stamina to withstand emergencies as well as everyday use.

To maintain their reputation for quality and dependability, U.S. Axle specifies only the finest materials, including Republic 4300 series hot rolled Alloy Steels.

These finest of steels provide the high strength, toughness, shock-resistance, and abrasion-resistance values needed to withstand the severe service to which the shafts and links are subjected. Alloy Steel's uniform response to heat treatment gives these parts hard surfaces around tough cores, providing maximum resistance to abrasion, friction, and wear.

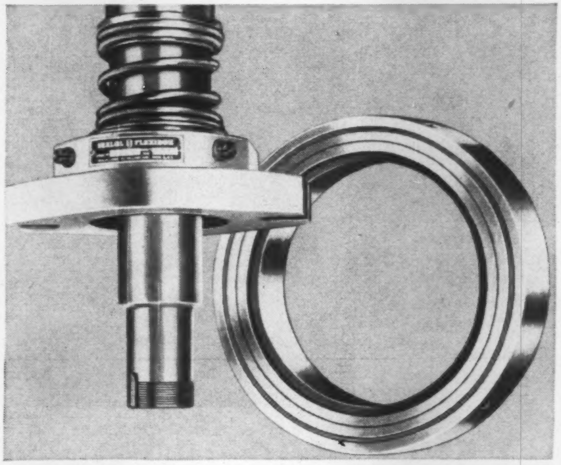
In Republic Alloy Steels you will find the highest strength values—plus an exceptionally high strength-to-weight ratio that permits the design of thinner sections to save weight and hold down size without any sacrifice of needed strength.

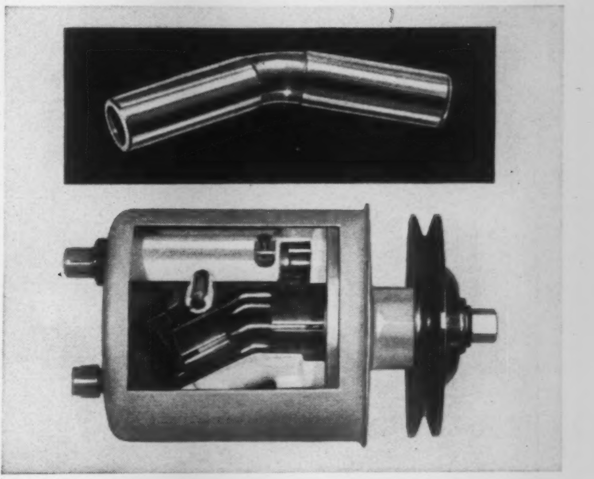
Specify Republic Alloy Steels to insure safety, to extend equipment life, to cut maintenance and replacement costs. Specify Republic Alloy Steels where strength and toughness must resist heavy-duty roughness. We offer you the services of our experienced field metallurgists to help you get the most from these versatile steels at the lowest possible cost. The coupon is your invitation to their services.



REPUBLIC DIE-FORM MEANS ECONOMY. This new fabricating process can save you 1 out of 3 tons of steel. The automotive transmission shaft, shown at left, proves the point. Using Die-Form, 200 tons of cold finished blanks produced parts formerly requiring 300 tons. Die-Form is a new method of cold forming hot rolled carbon, alloy, or stainless steel bars into multi-diameter blanks ready for final machining. It permits major savings in time, material, and money in mass produced, multi-diameter machine shafts. Since Die-Form closely approximates the final part, only finishing cuts and/or grinding are required for completion. Scrap loss is minimized—production rate increased. Send coupon for booklet describing the advantages of this new process.

REPUBLIC ENDURO® STAINLESS STEEL BARS provide a machine finish that looks as good as a ground finish. That's the performance report from machine operators at Sealol Corporation, Providence, Rhode Island. The company uses Free-Machining ENDURO bars in manufacturing mechanical shaft seals for application on fuel tankers, and in the aircraft, petroleum, food and chemical industries. The Sealol machine operators also report that they like the machinability of ENDURO bars—the fine surface finish, the accuracy of section, the uniform soundness, the ability of ENDURO to hold close tolerances. Send coupon for complete facts on Free-Machining ENDURO Stainless Steel Bars.





REPUBLIC ELECTRUNITE® MECHANICAL TUBING meets all close tolerance requirements for new automotive pump (above). The unusual ductility, uniformity, and workability of ELECTRUNITE Mechanical Tubing also meets the performance requirements of this hydraulic power pump designed and assembled by Thompson Products, Inc., Cleveland, Ohio. Will-O-Hill Industries, Inc., Willoughby, Ohio, subcontractor and specialist in close tolerance tubular stampings, cut $\frac{7}{16}$-inch diameter ELECTRUNITE into units $2\frac{3}{16}$ inches long. Each unit is rolled to form a slight groove in the center, and bent to an angle of exactly 150°. Both ends are subsequently bent in a die, held to a tolerance of $\pm .0005$ inches and finished to an O.D. to $\pm .0003$ inches. Republic Engineers will work with you in solving precision problems and reducing costs with ELECTRUNITE Mechanical Tubing. Send coupon today.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MD-5292
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Send more information on:
☐ Die-Form ☐ ENDURO Stainless Steel Bars
☐ ELECTRUNITE Mechanical Tubing
☐ Have an Alloy Metallurgist call.

Name____________________ Title__________

Company______________________________

Address______________________________

City______________ Zone_____ State________

thanks to automatic xerography...
NORTH AMERICAN AVIATION INC
X-15

Above: Harrison Storms, right, chief engineer at North American Aviation's Los Angeles division, examines 11" wide engineering-drawing reduction of the company's rocket-powered X-15 made xerographically on XeroX Copyflo 11 continuous printer. Buzz Holland, center, manager of photographic and reproduction services, explains process to Storms while Mark Keith, reproduction supervisor, holds 24" x 36" original drawing.

Inset: Ron Crawford inserts a 24" wide original drawing into Copyflo printer, which within seconds will deliver a dry, positive print into tray below.

North American Aviation SAVES $100,000 Yearly

North American Aviation, Inc., has figuratively gone supersonic in the rapid reproduction of engineering prints for high-speed aircraft.

This widely known aviation firm is one of the first in its field to install a XeroX® Copyflo® continuous printer, an ingenious machine that copies thousands of *different* drawings in a normal working day. Positive prints up to 11" wide emerge dry, ready for immediate use, at the rate of 20 linear feet a minute—a print in less than three seconds!

North American Aviation, Inc., is saving more than $100,000 annually through automatic xerographic copying, easily paying for the equipment the first year.

The Copyflo continuous printer accepts original documents or drawings up to 24 inches wide and of any length, and reduces or enlarges them to a maximum width of 11 inches. Copies are on plain unsensitized paper, offset paper masters, or translucent vellum. Originals may be in type, pencil, colored ink, or on tinted paper, yet copies will be precisely like the originals.

Simply push a button—and copies flow. Through versatile xerography—clean, fast, dry, electrostatic—Copyflo printers offer the speediest, most flexible, most economical way to get sharp, clear copies from all types of original documents or from microfilm.

For complete information write Haloid Xerox Inc., 58-188X Haloid St., Rochester 3, N. Y. Branch offices in principal U. S. and Canadian cities.

HALOID XEROX®

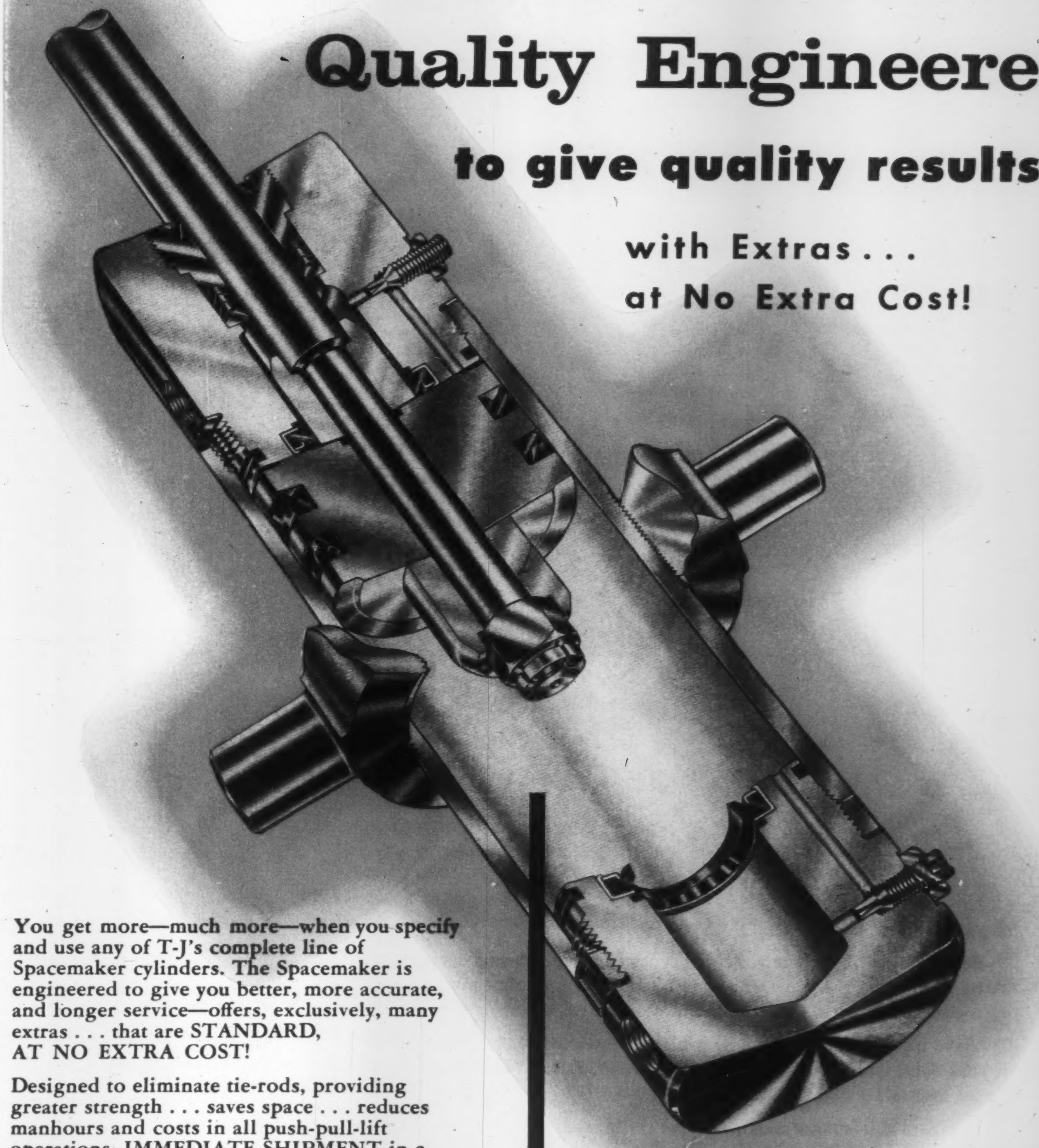
Circle 451 on Page 19

T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . . at No Extra Cost!



You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. IMMEDIATE SHIPMENT in a wide range of styles and capacities, with 64,000 combinations. Write for Bulletin SM 155-3 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

NEW "SUPER" CUSHION FOR AIR . . . Standard at No Extra Cost!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . Standard at No Extra Cost!

ONE PIECE PISTON . . . Standard at No Extra Cost!

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . Standard at No Extra Cost!

NO TIE-RODS TO STRETCH . . . Standard at No Extra Cost!

STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

FORGED SOLID STEEL HEADS . . . Standard at No Extra Cost!

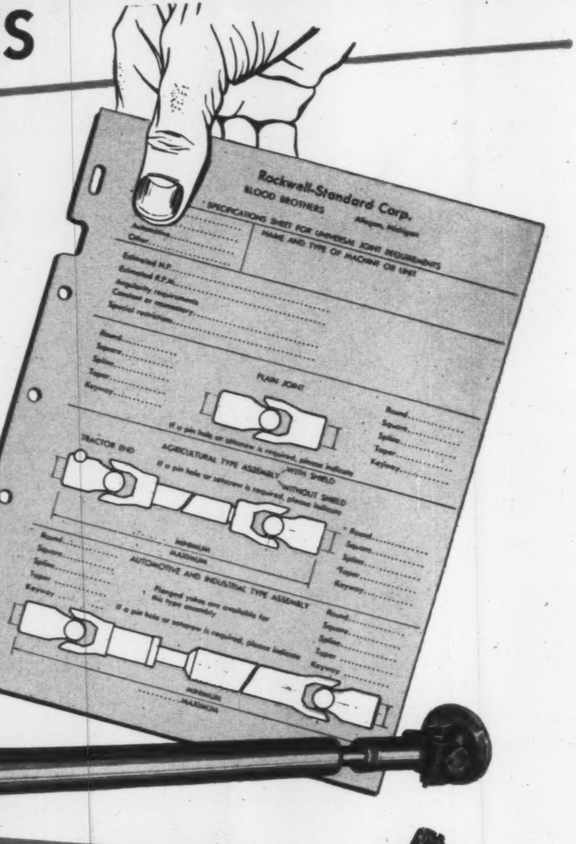
Circle 452 on Page 19

BLOOD BROTHERS works with you to HELP CUT COSTS

... when your project requires a simple universal joint like this ...

... a complete agricultural type assembly ...

... or automotive and industrial units like these:


Rockwell-Standard Corp.
BLOOD BROTHERS
SPECIFICATIONS SHEET FOR UNIVERSAL JOINT REQUIREMENTS
PLAIN JOINT
AGRICULTURAL TYPE ASSEMBLY
AUTOMOTIVE AND INDUSTRIAL TYPE ASSEMBLY

YOU CAN SAVE MONEY TWO WAYS:

ONE—Have Blood Brothers review *all* joint and drive line specifications and costs for your *current models*. You'll help *insure* the lowest-cost purchasing of components that fulfill specifications. It's easy to submit data on "Spec Sheets" like that above—or if you wish, send us your engineering drawings.

For example, one maker of eight types of machines cuts costs by using only three sizes of joints. This means smaller inventories, fewer parts to catalog and stock, and volume prices.

TWO—Save time at the start of new projects by sending us a "Spec Sheet" with your data. Our engineers will submit drawings and recommendations that may forestall problems later.

Blood Brothers builds more standard types and sizes of universal joints than any other manufacturer—and will gladly work with you to help cut costs.

Just write or call—and request your supply of handy blank "Spec Sheets" for use now or later.

ROCKWELL-STANDARD CORPORATION
(Formerly Rockwell Spring and Axle Company)

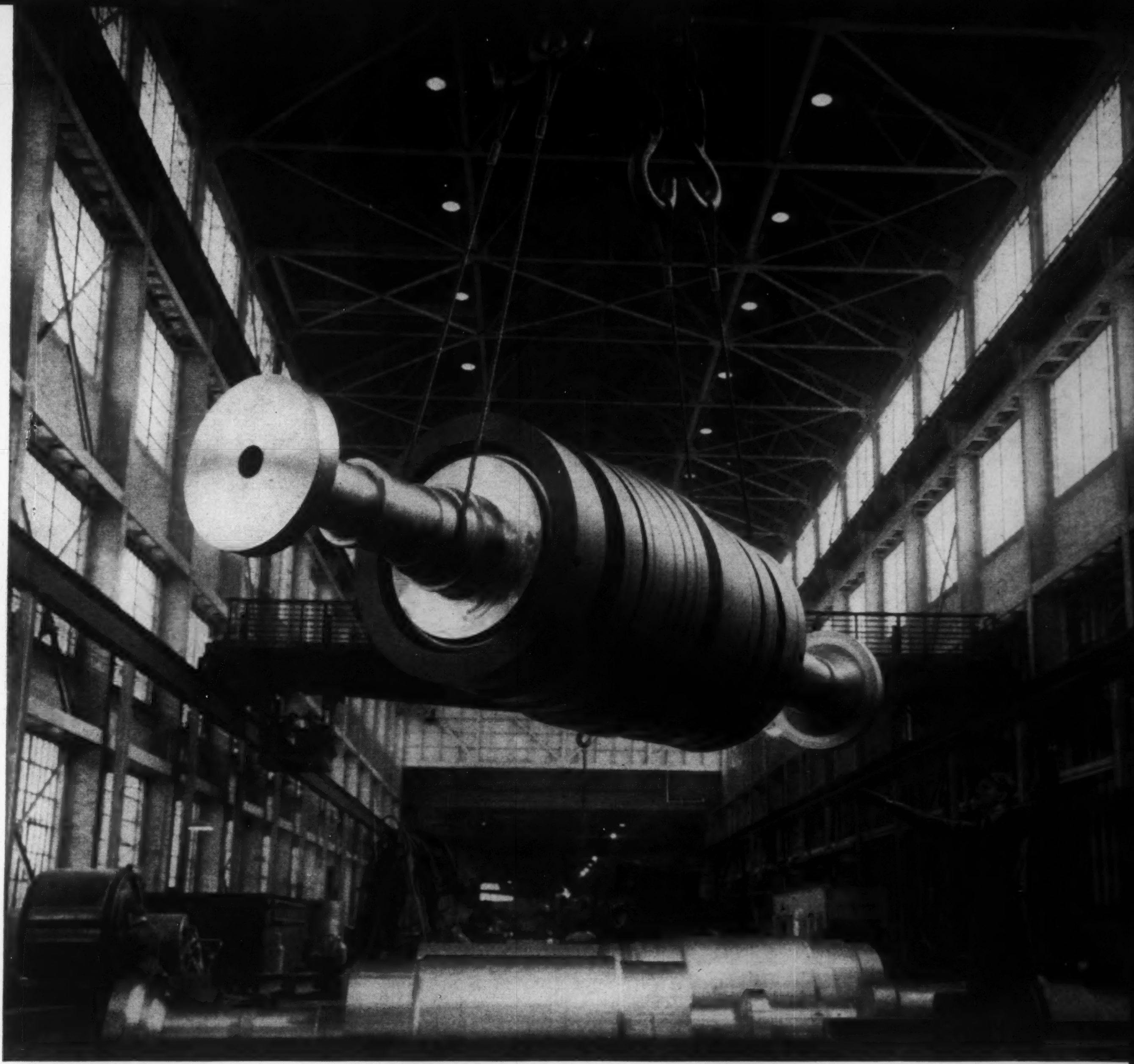
Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

ROCKWELL R STANDARD
BB UNIVERSAL JOINTS

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

© 1958, Rockwell-Standard Corp.



Its Job is to Help Produce Power

As the public utilities race to keep up with demands for more and more power, forgings like this become increasingly important. The one you see here is a steam-turbine spindle, and it will soon be doing its part in the large-scale production of kilowatts.

Bethlehem press-forged the spindle from an alloy-steel ingot containing molybdenum, chromium, nickel, and vanadium. Then the Bethlehem machine shops took over and worked carefully to exacting specifications. When ready for shipment, the spindle weighed 28 tons; was 18 ft 6 in. long.

This is just one of the many types of forgings that Bethlehem makes each year. Our shops are equipped to produce the largest, the smallest, and everything in between. Whether you need tiny drop forgings or huge shafts weighing a hundred tons, we can make and machine them for you. Call us and draw upon our half-century of experience.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

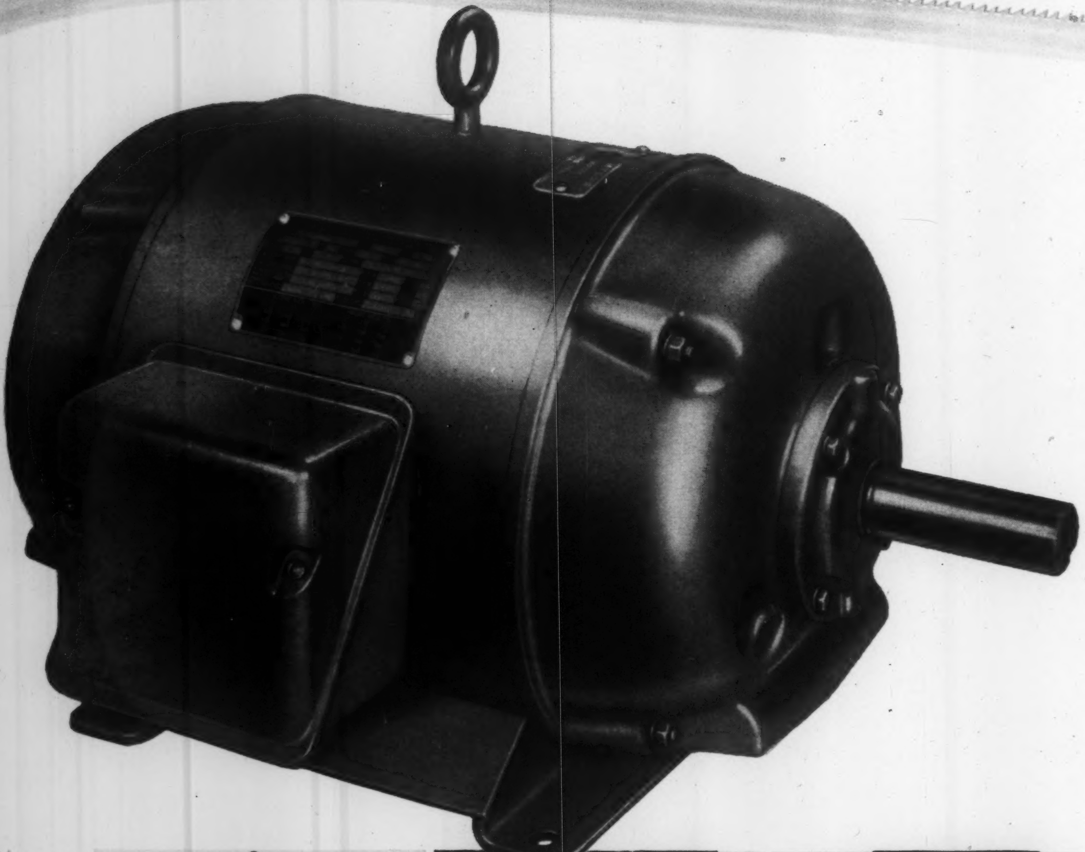
BETHLEHEM STEEL

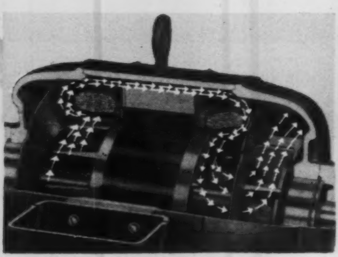
BETHLEHEM STEEL

Circle 454 on Page 19

Robbins & Myers

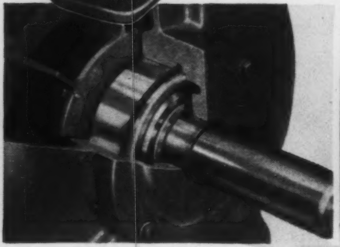
helps





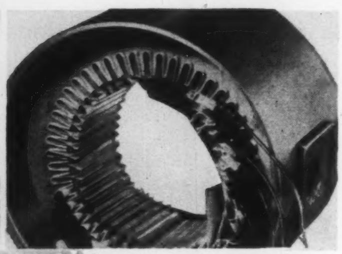
Highly efficient dual-sweep ventilation

Tandem fans, one pushing and one pulling, cool motor from end to end ... air-wash field coil ends ... eliminate "hot spots" ... greatly prolong motor life!



Fully sealed prelubricated bearings

Run in double-width races ... have extra-large lubricant reservoirs ... seldom need re-lubrication ... are quickly, easily inspected by removing cover plates!



Life-prolonging *Mylar insulation

Has excellent dielectric qualities ... resists tearing and aging ... assures virtually permanent protection. Rag paper backing cushions against abrasions and punctures!

* DuPont registered trademark

MOTOR STAMINA

DoALL *machines saw their way to success!*

DoALL Contour-matic Band Machine

The DoALL Company equips its versatile Power Saws and Contour-matic Band Machines with sturdy, dependable R&M motors. These motors are precision-built, with ample reserve power that helps DoALL achieve record-breaking cutting rates while working at greater feed and speed pressures.

In thousands of DoALL-equipped plants, R&M motor stamina has proven itself. R&M motors take toughest DoALL jobs in stride—powering their new Demon high-speed steel cutting tool in the machining of harder-to-cut tough new alloys. DoALL versatility depends on reliable power to saw, file, grind or polish all materials. The same strong R&M motor also drives the machine's hydraulic and air pumps, providing smooth power for automatic stock feeding, work table positioning, etc.

If your product requires heavy duty motors designed for faster, more versatile production, plus top dependability, Robbins & Myers can help you.

Contact your R&M representative or write today for Bulletin 520-MD

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

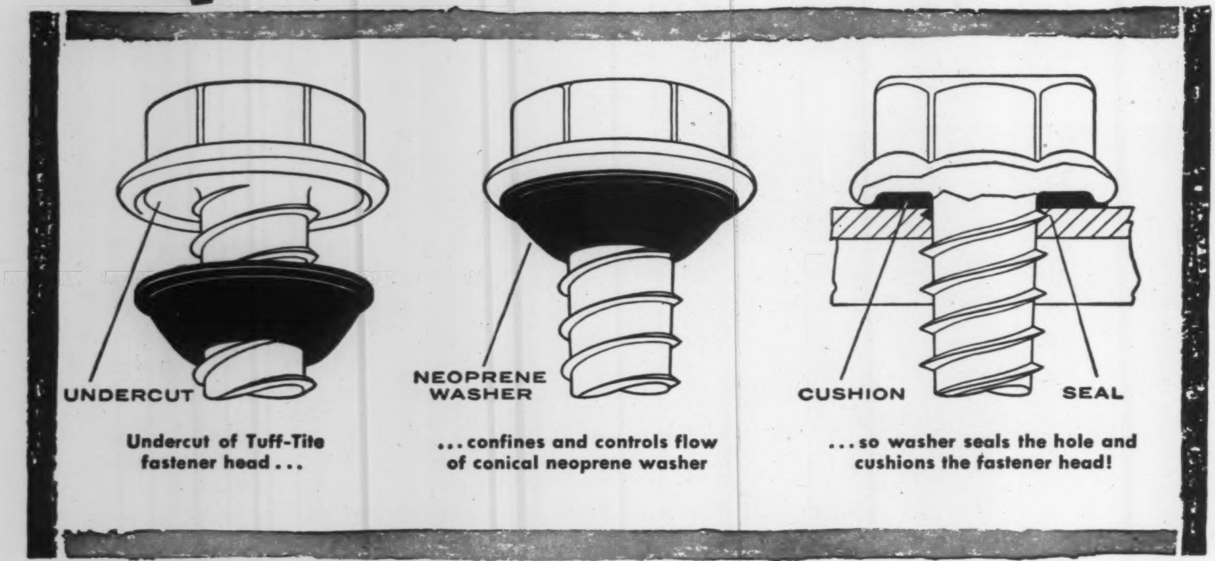
MOTORS · FANS · HOISTS · MOYNO® PUMPS · (INDUSTRIAL) PROPELLAIR® FANS

R&M builds motors from 1/200 to 200 horsepower

Circle 455 on Page 19

For better products

LEAKPROOF...CUSHIONED TUFF-TITE® FASTENERS



Undercut of Tuff-Tite fastener head . . .

. . . confines and controls flow of conical neoprene washer

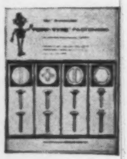
. . . so washer seals the hole and cushions the fastener head!

Now you can
- prevent leaks at fastener holes
- protect fine finishes from fastener damage
- stop vibration noises and squeaks

It's the combination of undercut head design and tough, conically shaped neoprene washer that makes Tuff-Tite fasteners work. The undercut helps confine and control spread of the neoprene washer as it is compressed. The washer's conical shape causes it to flow into top threads and seal the fastener hole.

Tuff-Tite fasteners won't mar fine finishes and they stop vibration noises and squeaks because the neoprene washer spreads itself completely between fastener head and surface. The washer actually cushions the fastener and prevents metal-to-metal contact.

Leakproof, non-marring, shock and squeak absorbing! If you need these fastening advantages, you need National Tuff-Tite fasteners. Write for the Tuff-Tite fastener folder describing this line in detail.



THE NATIONAL SCREW & MFG. COMPANY
CLEVELAND 4, OHIO
***Pacific Coast:* National Screw & Mfg. Co. of Cal.**
3423 South Garfield Ave., Los Angeles 22, Cal.

Tuff-Tite fastener facts

Standard National Tuff-Tite fasteners are available in hexagonal, pan, round and truss head styles for screw diameters No. 6 to $\frac{3}{8}''$ inclusive . . . maximum over-all length $1\frac{1}{2}''$. Standard fastener types are wood screws, self-tapping screws, thread cutting screws, machine screws and stove bolts. Tuff-Tite fasteners are pre-assembled with neoprene washers.

Washers are molded of neoprene which has a durometer hardness of 85 to 95.

Write for information on *special* Tuff-Tite fasteners.

National PRODUCTS

Fasteners **Hodell Chains** **Chester Hoists**

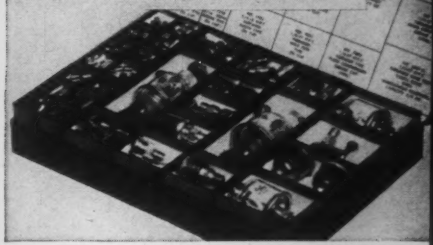
Help Satisfy the "Low Cost" Requirements of Your Design

GITS

World's Largest Selection of LUBRICATING DEVICES

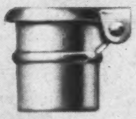
LUBRIKIT... An assortment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

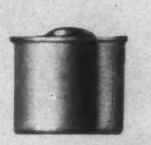
Special Introductory Price
Just $14^{95} F.O.B. Factory
Satisfaction or your money back

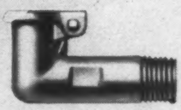


OIL HOLE COVERS

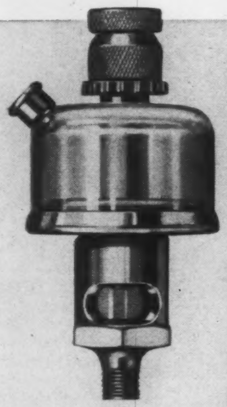
Style R — No. 304
Shoulder Drive


Style G — No. 505
Beaded Drive


Style GB — No. 527
Ball Valve

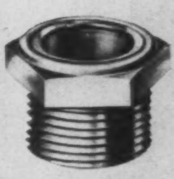

Style L — No. 1204
Brass Elbow (Threaded)

SIGHT GRAVITY FEED OILERS



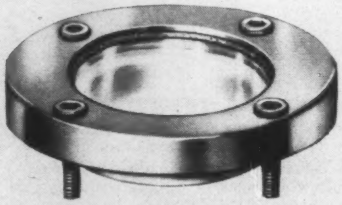
Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES



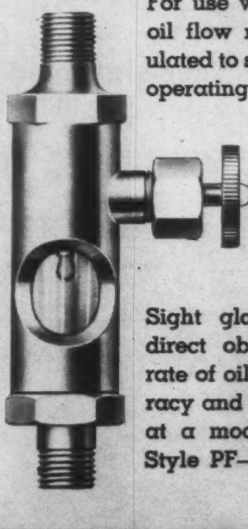
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

GEAR CASE GAUGES



Screw mounted, to set flush. Glass port is backed with white enameled reflector, to make oil level (in gear case or transmission) readily visible, even in dim light. Style CW — No. 4032.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

GITS BROS. MFG. CO.
The Standard For Industry For Almost Half A Century
1868-C South Kilbourn Avenue
Chicago 23, Illinois

Clip this page for handy "rough reference"

Circle 457 on Page 19

STOPPED!

LOST
10,000 man-hours

and your high-paid help talks TV

Stopped . . . because automatic control circuits and operating elements were not designed on the modular basis, with Cannon quick-disconnect electrical connectors at vital points.

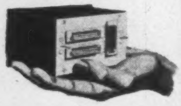
But it could have been rolling in seconds or minutes! If only the circuitry had been arranged on the modular basis so that essential elements of the automatic control and operating system could be disconnected quickly . . . and complete, operable spare components inserted at a moment's notice. The units in trouble could have been repaired properly, too, at leisure . . . by trained personnel, at the right place, with the right facilities. Production could have gone on . . . thousands of man-hours and thousands of dollars saved . . . merely by the use of quick-disconnect components.

Are the controls in your electrical or electronic product designed on the modular basis? How about your production line? Will minor failure cause breakdown? Or do you need Cannon Connectors? Cannon makes over 27,000 different electrical connectors. If one of these does not meet your requirements, we'll design and make the electrical connector you need. Write today! Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. Please refer to Dept. **185**.

Send for explanatory material on how modular designs can save dollars.

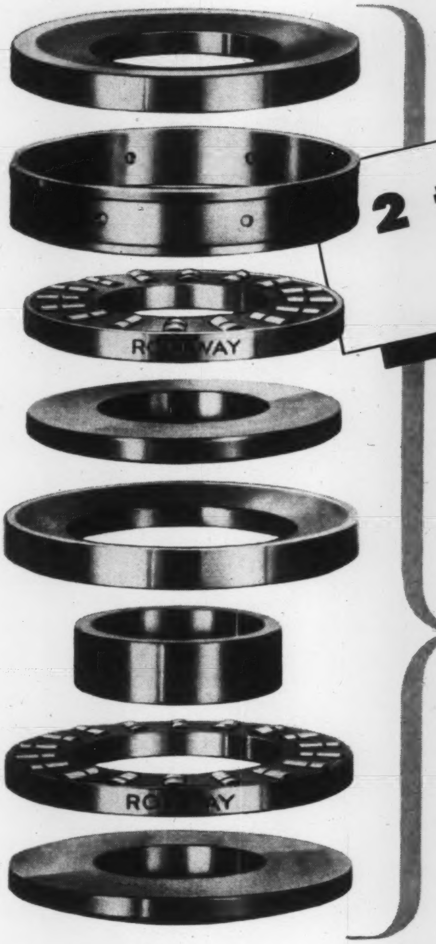
CANNON PLUGS

CANNON ELECTRIC



Where Reliability for Your Product is Our Constant Goal

COPYRIGHT 1958, CANNON ELECTRIC CO.



**2 to 3 times
Greater Thrust Capacity**

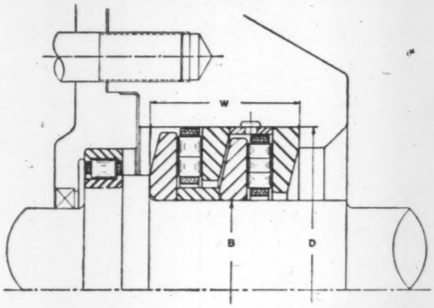
**8 to 12 times
Longer Life Expectancy**

New ROLLWAY
TANDEM THRUST BEARING

Using axial space along the shaft, rather than enlarging the housing diameter, this new Rollway tandem thrust bearing distributes the load over two or three stages of roller components. Gives 2 to 3 times more thrust capacity than conventional thrust bearings. Life expectancy is 8 to 12 times longer depending upon the number of stages.

Each stage comprises a rotatable bearing plate . . . a bronze retainer with thru-hardened steel rollers . . . a compression sleeve . . . and a stationary bearing plate. The thrust load is applied to the first stage and is by-passed by each compression sleeve in turn to the remaining stage or stages.

Calculated deformation of the bearing plates distributes the load uniformly on all rollers. A greater number of rollers in the first stage carries about 60% of the load, without increasing the load per roller. Compression sleeves have cross-sectional areas proportional to the load imposed. Roller variance is held within one ten-thousandth inch.



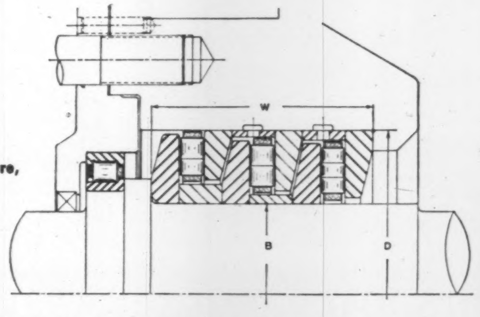
✓ **TWO STAGE TANDEM**

22 sizes, up to 17" bore, 34" O.D., and 2,325,000 lb. capacity at 100 rpm

SEE this remarkable bearing at the AISE Show (Booths 479-80), or write Rollway Bearing Company, Inc., 541 Seymour Street, Syracuse 4, N.Y. for catalog sheet giving complete specifications.

✓ **THREE STAGE TANDEM**

5 sizes, up to 17" bore, 34" O.D., and 3,410,000 lb. capacity at 100 rpm



**ROLLWAY
BEARINGS**

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

Tandem Thrust Bearing manufactured by Rollway Bearing Company, Inc.
under U.S. Patent Number 2,374,820.

ENGINEERING OFFICES: Syracuse • Chicago • Toronto • Cleveland • Seattle • San Francisco • Boston • Detroit • Pittsburgh • Houston • Philadelphia • Los Angeles

TIMERS...SPECIAL DELIVERY

Standard or special— Industrial Timer makes rapid deliveries on all models

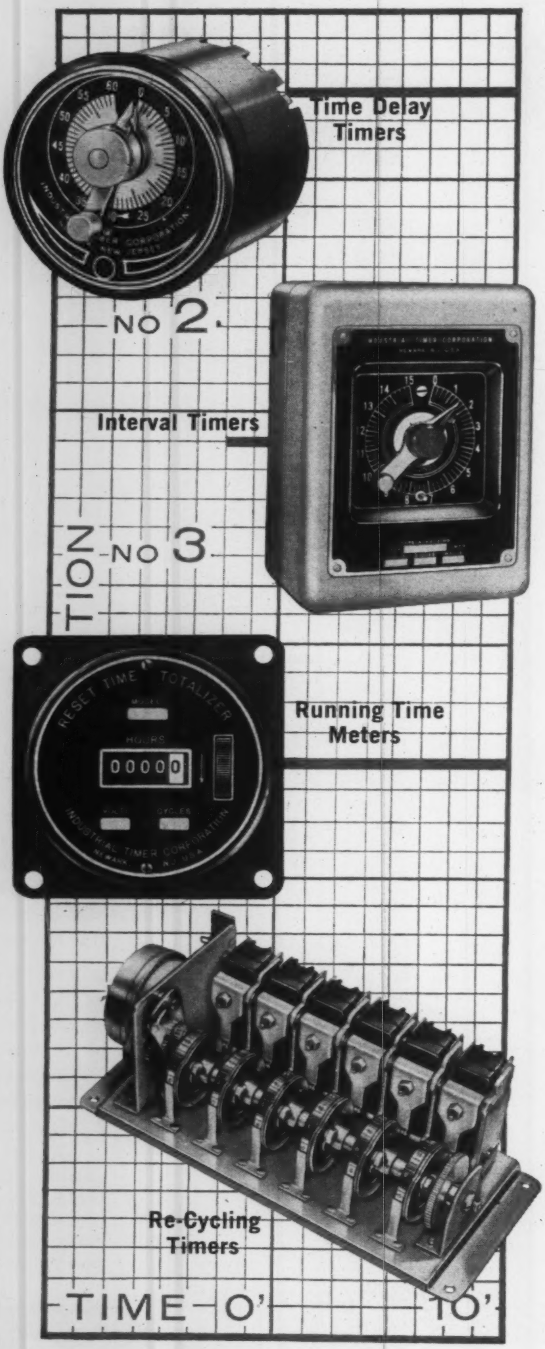
Sometimes you need a standard model timer . . . other times you need a special. Either way we can give you the extra rapid service you may need because of the efficient way we design, manufacture and stock timers for industrial applications.

To meet *all* of the widely varying needs of our customers we manufacture a complete line of timers in the four broad classifications illustrated here:

1. **TIME DELAY TIMERS**
2. **INTERVAL TIMERS**
3. **RE-CYCLING TIMERS**
4. **RUNNING TIME METERS**

From these we have already developed 20 basic types which can be combined in endless number of ways . . . to date, our engineers have combined them into over 1000 different models. So what might seem to be a special timer requirement to you, will very often be a standard timer in our large stock, and that is the reason we have the ability to fill special orders so quickly. And as far as standard timers are concerned we can give overnight service if necessary.

So, for the utmost in all-round service depend on us for this outstanding combination: deliveries "Immediate on Standards . . . First on Specials".



Speed up your automatic control projects— profit by our timing application experience

No need to let timing problems delay you in your automatic control projects when you can place them with us and get faster solutions. Even though no two automatic control jobs are ever exactly alike, and even though the timer requirements of each are very different we have established an excellent record in helping out in these situations.

20 years of experience in analyzing complex timer applications has provided us with the special knowledge required to give our customers the right answer in near-record time.

Our large stock of standard and combination timers enables us very often to fill orders for these requirements without any time loss because we have already developed so many new combinations specifically for automatic control functions.

Extra special automatic control timer — this calls for original designing. Our engineers will go right to work and get the job done. That's the way we grow and we like it.

Whatever your control problem, you have everything to gain by submitting it to our timer specialists. They'll come up with the answer — almost with the speed of automatic control itself.

AFFILIATE—LINE ELECTRIC COMPANY

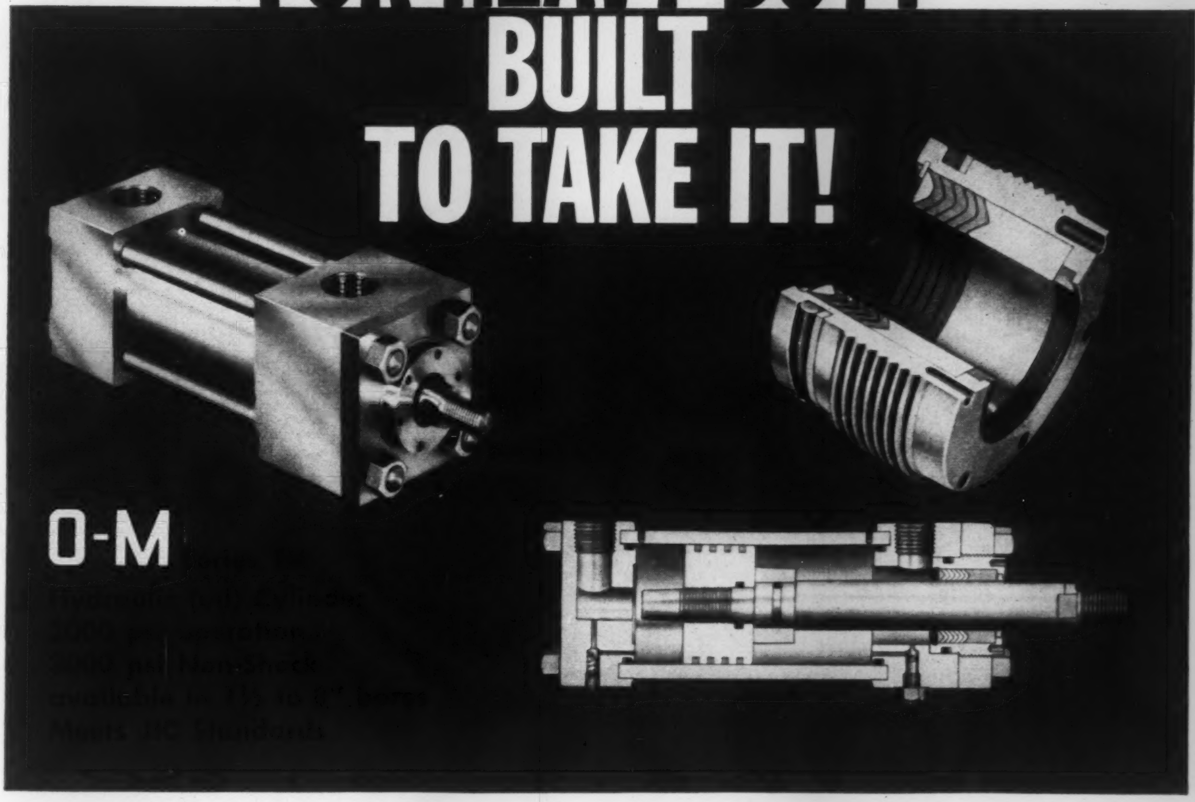
Timers that Control
the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION
1413 McCARTER HIGHWAY, NEWARK 4, N. J.

Circle 460 on Page 19

DESIGNED FOR HEAVY DUTY BUILT TO TAKE IT!



O-M [illegible]
Hydraulic Tie-rod Cylinder;
2000 psi operation
3000 psi Non-Shock
available in 1½ to 8" bores
Meets JIC Standards

Every engineering and construction detail of the improved O-M Tie-rod Hydraulic Cylinder adds to its overall operating efficiency under heavy work loads, assuring maximum smooth performance with minimum maintenance. It is ruggedly constructed of heavy walled, seamless steel tubing microhoned to minimize friction. The rolled steel heads are recessed to confine the tube, prevent breathing and to provide additional protection against leakage under the most severe conditions. Heads can be rotated independently at 90° intervals for convenient port location. The piston rod is of stress relieved, high tensile steel, hard chrome plated, turned, ground and polished. The rod gland cartridge that is threaded for quick, easy removal, is accurately piloted in rod head to assure perfect alignment, also serves as pilot for cylinder mounted on rod end. Rod gland contains extra long bronze rod bearing for maximum support of piston rod.

Vee type, non adjustable, self compensating, rod gland packing provides multiple lip seal. Cartridge "O" ring, with leather back up furnishes a positive seal. Rod wiper or interchangeable metallic scraper prevent dirt from entering cylinder on "in" stroke. A complete selection of mounts is available.

These and many other features are described in detail in our latest catalog No. 105. Write for your copy TODAY or consult your local O-M representative.

ORTMAN-MILLER MACHINE COMPANY
7 143rd Street, Hammond, Indiana

☐ Have representative call
☐ Send Bulletin 105

Name________________________Position__________

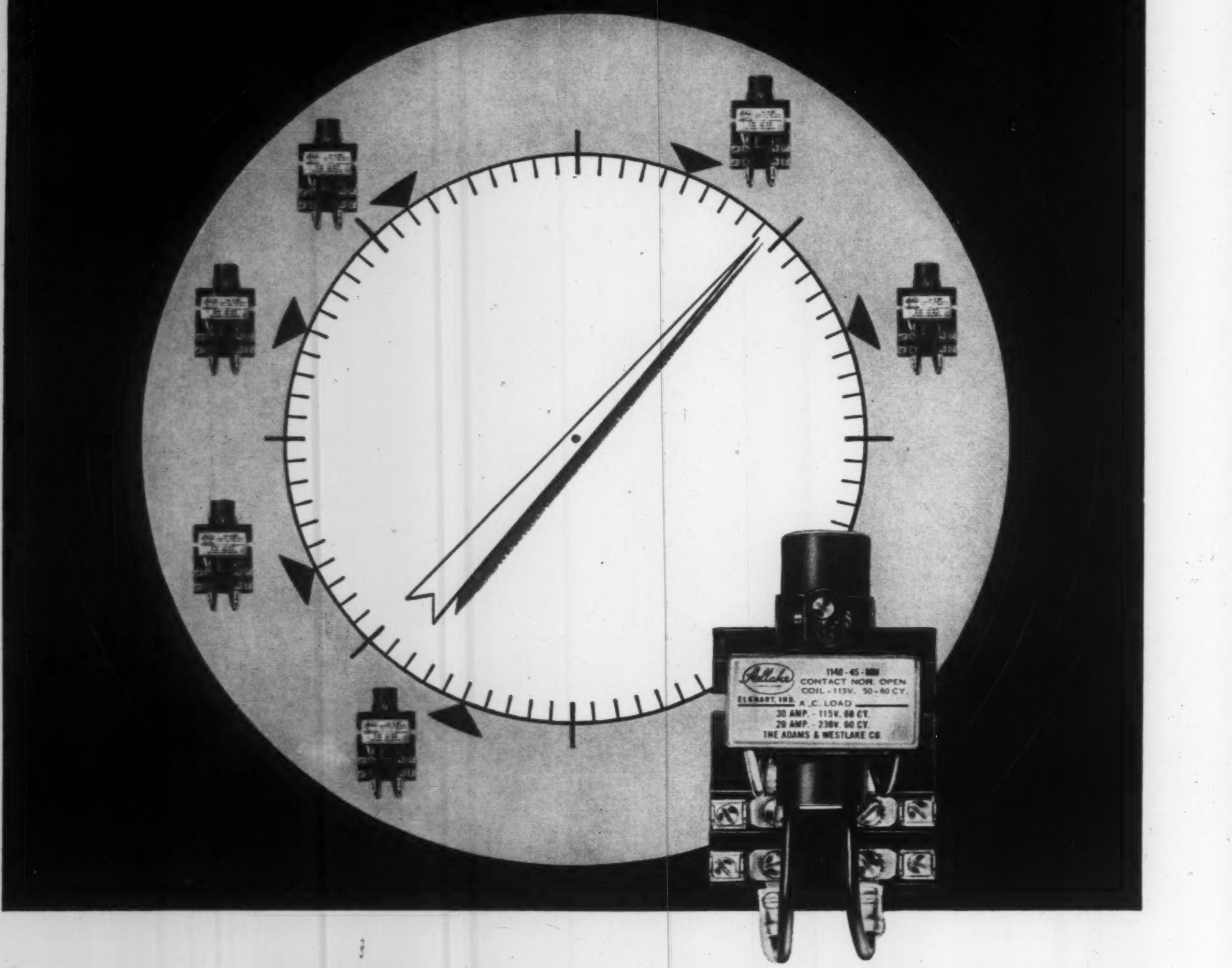
Company____________________________________

Address_____________________________________

City__________________Zone_____State__________

Circle 461 on Page 19

When You Need Reliable Control of Sequential Functions



you need Adlake mercury-to-mercury relays

From sensitive laboratory use to rugged locomotive application, Adlake relays have proved their dependability and versatility. Here's why:

- **Perfect snap action—no pitting, burning or sticking**
- **Hermetically sealed at the factory—no intrusion of dust, dirt or moisture**
- **Fixed, tamper-proof time delay characteristics**
- **Quiet, chatterless operation. No maintenance whatever.**

Our engineers will gladly help you solve your control problems—no obligation. Just write The Adams & Westlake Company, 1173 N. Michigan, Elkhart, Indiana...New York...Chicago

The Adams & Westlake Company
NEW YORK ELKHART, INDIANA CHICAGO
Established 1857

RECEIVING ENTHUSIASTIC ACCEPTANCE

VICKERS® New ¼" Temperature and Pressure Compensated FLOW CONTROL VALVE

For years the Machine Tool Industry has been asking for a combination Temperature and Pressure Compensated Flow Control Valve to minimize feed rate changes. Now for the first time it is available as a production unit at a reasonable price.

VICKERS
FLOW CONTROL & CHECK VALVE
MODEL
A
VICKERS INC DETROIT USA
ANOTHER VICKERS FIRST

FOR OPERATING PRESSURES UP TO 2000 psi

Check THESE EXCLUSIVE FEATURES that mean Optimum Tool Life and Better Work Finish:

☑ **TEMPERATURE COMPENSATED**
Virtually constant feed rates all day long with same throttle setting because throttle automatically compensates for changes in oil temperature. The compensator mechanism is simple in design and durable.

☑ **PRESSURE COMPENSATED**
Constant feed rate throughout entire cycle because built-in pressure hydrostat automatically compensates for load changes.

☑ **SINGLE THROTTLE COMPLETE RANGE ADJUSTMENT**
Greater flexibility because valve is adjustable within entire flow range of 5 to 1000 cubic inches per minute.

☑ **REVERSE FREE FLOW AS STANDARD FEATURE**
A standard feature which permits reverse free flow (up to 1400 cu. in. per min.) from outlet to inlet port by-passing control elements.

☑ **TAMPER-PROOF ADJUSTMENT**
Retension of original feed rate is assured because a set screw prevents inadvertent throttle movement and a cover over the set screw can be locked in place.

☑ **INTERCHANGEABLE**
This new valve replaces 12 previous models and it is interchangeable with all of them, also the drain connection is eliminated on the new valve to simplify piping.

☑ **GREATER ECONOMY**
No need to stock several valves for wide range of flow rates. Drain connection is eliminated, piping costs are reduced.

☑ **MAXIMUM RELIABILITY AND ACCURACY**
Design of temperature and pressure control components assures maximum circuit reliability and extreme accuracy of feed through a range of 5 to 1000 cubic inches per minute.

FOR ADDITIONAL INFORMATION SEND FOR I-195040

8143

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: ATLANTA • CHICAGO • CINCINNATI
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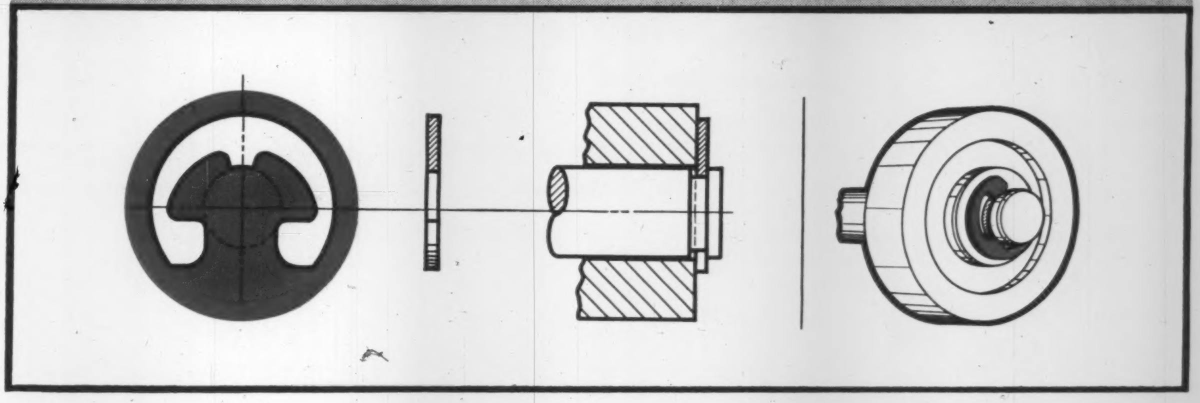
FACTORIES ALSO IN AUSTRALIA, ENGLAND AND GERMANY
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto and Montreal

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

New Waldes Truarc Reinforced "E-ring" Provides 5 Times More Gripping Power, 50% Higher RPM Limits Than Conventional E-Type Rings



The new Waldes Truarc Series 5144 is a radially-installed reinforced "E-ring." It is designed for use in assemblies where the ring is subject to strong push-out forces resulting from heavy vibration and shock loads, high rotational speeds or relative rotation between the retained parts.

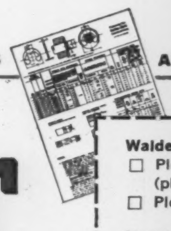
Series 5144 provides the following application advantages over conventional E-type fasteners:

1. **GREATER GRIPPING STRENGTH**—approximately five times greater than conventional "E-rings" of the same metal and thickness.
2. **HIGHER RPM LIMITS**—approximately 50% higher in most sizes.
3. **POSITIVE LOCKING IN THE GROOVE**—large corner radii or chamfers can be accommodated without separator washers.
4. **LOWER GROOVE COSTS**—because recommended groove tolerances have been increased, machining grooves for the series 5144 is less expensive.
5. **WIDER APPLICATION**—because series 5144 rings made of aluminum are stronger than conventional "E-rings" made of steel, the fastener may be used in applications where corrosion resistance or weight are factors.

Truarc Series 5144 Reinforced "E-rings" are available for shaft diameters from 3/32—7/16 in. in carbon spring steel, stainless steel, beryllium copper, aluminum, and phosphor bronze. They are available stacked on rods for high speed installation with Truarc applicating and dispensing equipment.

As in all Truarc rings, you get statistically controlled quality from engineering and raw materials to the finished product. Complete selections are available from leading OEM distributors in 90 stocking points throughout the U. S. and Canada. Design Engineering Service is available to you. Send us your blueprints. Let our Truarc engineers help you solve design, assembly and production problems . . . without obligation.

SEND FOR FREE SAMPLES AND ENGINEERING DATA



WALDES
TRUARC®
RETAINING RINGS®

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, N. Y.

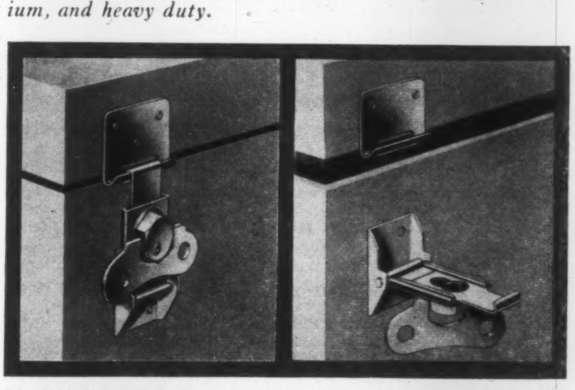
Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.
☐ Please send me sample Reinforced "E-rings." (please specify shaft size)____
☐ Please send me Engineering Data Sheet
Name____
Title____
Company____
Business Address____
City____ Zone____ State____
MD-090

Consult the Yellow Pages of Your Telephone Directory for Name of Local Truarc Factory Representative and Authorized Distributor. Look under "Retaining Rings" or "Rings, Retaining."

Zero cases, sealed pressure-tight by LINK-LOCK,

guard instruments against humidity, dust, atmospheric pressure changes

Simmons No. 3 LINK-LOCK fasteners are employed on these deep-drawn aluminum Zero transit cases. LINK-LOCK is available in three sizes, for light, medium, and heavy duty.



No. 2 LINK-LOCK. Half turn applies high closing pressure, counter-turn disengages for opening.

Delicate electronic and optical equipment is shipped long distances . . . handled again and again . . . and sometimes stored for long periods in transit cases manufactured by the Zero Manufacturing Company, Burbank, California.

The unique containers shown here are deep-drawn aluminum, seamless, with precision-fitting gasketed lids. They comply with rigid military specifications, insuring protection of contents against humidity, dust, and variations in pressure.

To effect the critically important pressure-tight seal, Zero specifies Simmons LINK-LOCK fasteners.

Here's why LINK-LOCK is ideal for use on precision-built military cases as well as on inexpensive commercial containers:

- Positive-locking without springs.
- Impact and drop resistant; not affected by arctic temperatures.
- Compact design—lies flat open or secured.
- Latch design can be varied to suit different applications.
- High preloading and high load-carrying capacity.

WRITE FOR CATALOG NO. 1257

It contains specifications, drawings, details of LINK-LOCK and other Simmons Fasteners with unlimited money-saving applications.

SIMMONS FASTENER CORPORATION
1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK • HINGE-LOCK

See our 8-page catalog in Sweet's Product Design File

Reliability—Everyone has a different picture of reliability. To millions of us, it means an unthinking faith in the slender steel ropes that hoist an elevator car. To the captain of a ship, it's a staunch steel hull that will resist the wrack of any storm. To the policeman on the beat, it's the oil-smooth action of a steel revolver that must never fail.

So it is that whenever man decides to make something that is completely reliable, he usually makes it from steel. The reason is simple: steel is the strongest, toughest material on this planet that can be bought at a reasonable price.

More than that, it's so easy to *use*. With heat treatment, most steels can be made soft enough to work, then strong enough to carry the load, then tough enough to take the pounding of any application. With many steels, you can achieve 100% efficient welded joints. All this in a material that is universally available, in an infinity of grades, shapes, sizes, finishes and preforms.

Ironically, the great *variety* of steels often causes trouble for the designer. No matter what combination of properties you need, no matter what the application, there is theoretically one best steel for the job. Finding it among the great family of Carbon, High Strength, Alloy and Stainless Steels can be a problem unless you have a skilled metallurgist on your staff, or unless you take advantage of the free services of a company that has invested hundreds of millions of dollars in steel research—this is United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

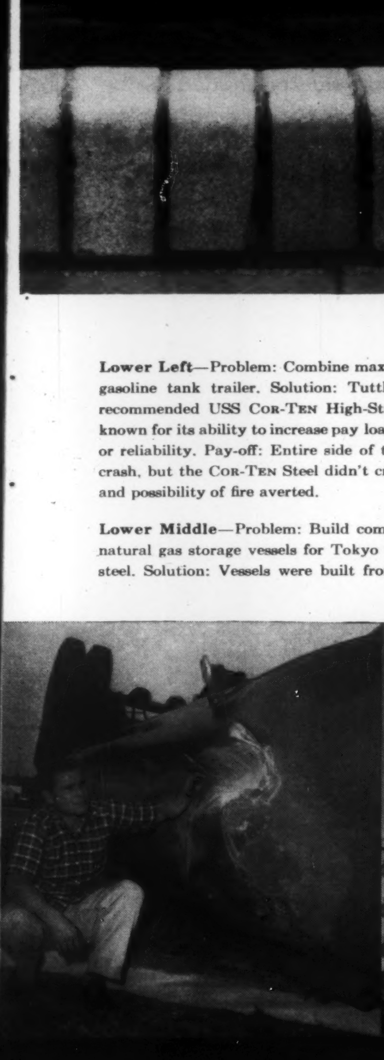
STEELS FOR DESIGN

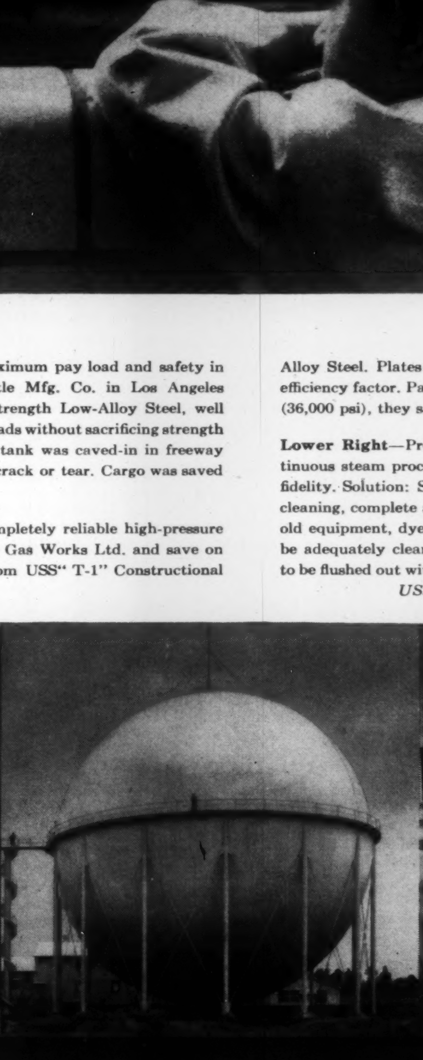
Lower Left—Problem: Combine maximum pay load and safety in gasoline tank trailer. Solution: Tuttle Mfg. Co. in Los Angeles recommended USS Cor-Ten High-Strength Low-Alloy Steel, well known for its ability to increase pay loads without sacrificing strength or reliability. Pay-off: Entire side of tank was caved-in in freeway crash, but the Cor-Ten Steel didn't crack or tear. Cargo was saved and possibility of fire averted.

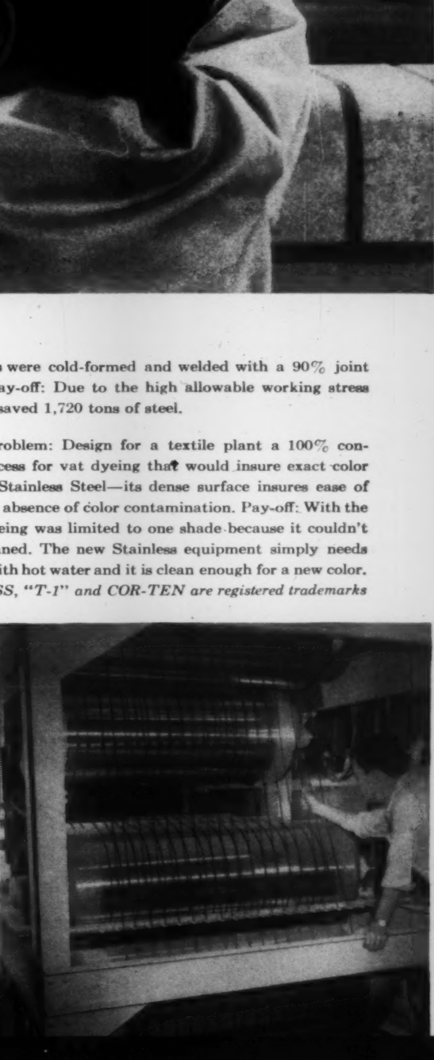
Lower Middle—Problem: Build completely reliable high-pressure natural gas storage vessels for Tokyo Gas Works Ltd. and save on steel. Solution: Vessels were built from USS "T-1" Constructional Alloy Steel. Plates were cold-formed and welded with a 90% joint efficiency factor. Pay-off: Due to the high allowable working stress (36,000 psi), they saved 1,720 tons of steel.

Lower Right—Problem: Design for a textile plant a 100% continuous steam process for vat dyeing that would insure exact color fidelity. Solution: Stainless Steel—its dense surface insures ease of cleaning, complete absence of color contamination. Pay-off: With the old equipment, dyeing was limited to one shade because it couldn't be adequately cleaned. The new Stainless equipment simply needs to be flushed out with hot water and it is clean enough for a new color.

USS, "T-1" and COR-TEN are registered trademarks





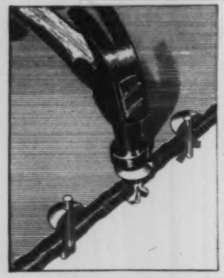


MANY FACTORS CONTRIBUTE TO LOW INSTALLED COST OF SOUTHCO DRIVE RIVETS . . .

ECONOMICS OF FASTENING COVERS FULL CYCLE FROM INVENTORY REQUIREMENTS TO FINISHED PRODUCT

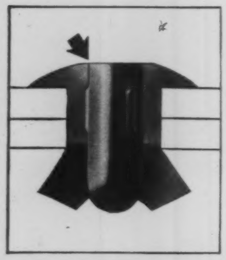
Designers who specify fasteners realize the many considerations that enter into cost determination. While ease of installation is often the most important feature, other factors affect costs. It may be difficult to put a dollar value on availability, for example, but serious financial losses do occur when production is held up or shipping dates are missed because of a slow fastener delivery. Being able to ship from stock, as Southco does, helps avoid production delays.

ELIMINATION OF SPECIAL TOOLS



Down time due to special tool failure and maintenance of special fastening tools are two fastening costs which are eliminated by Southco Drive Rivets. The only tool required is a hammer . . . any kind of a hammer . . . claw or ball, and size is not important. The number of men on a Southco riveting job is never limited by the number of special tools on hand and in working order.

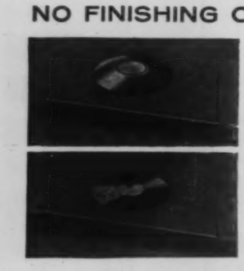
QUICKLY SET



To install, Southco Rivets are placed in drilled hole. The pin is then driven with a hammer. Installation is complete. No bucking is required.

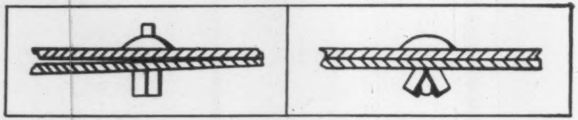
Expanded prongs force parts together. Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

NO FINISHING OFF, NO WASTE



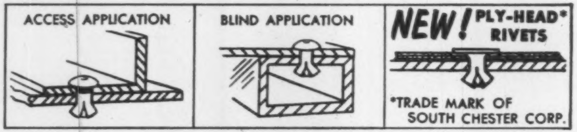
Impact of hammer seals pin neatly in rivet. No part of the rivet is cut off and discarded. No time-consuming filing, grinding or polishing is necessary. No scrap to clean up.

AUTOMATIC "PULL-UP" ACTION ASSURES TIGHT JOINT



Even when adjacent surfaces are separated, parts are forced together by Southco Rivet action, then held tightly in compression.

WIDE RANGE OF APPLICATION



Southco Drive Rivets are used to secure metal to metal or metal to wood. They are equally adaptable to blind or open applications. In each, they are quickly set and grip tightly. New PLY-HEAD* rivet permits higher loading of "soft" materials such as plywood, plastics and composition.

AVAILABLE IN ALUMINUM OR STEEL

Southco Rivets are supplied in aluminum or cadmium plated steel. The aluminum rivets have either cadmium plated or stainless steel grooved pins. The steel rivets have cadmium plated steel grooved pins.

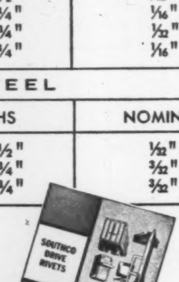
Standard head designs are Universal or Countersunk. Full Brazier heads are available in popular sizes. New PLY-HEAD rivet rounds out line.

ALUMINUM

DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
5/32"	7/32" to 3/4"	1/16" to 5/8"
3/16"	1/8" to 3/4"	1/32" to 5/8"
1/4"	7/32" to 3/4"	1/16" to 5/8"

STEEL

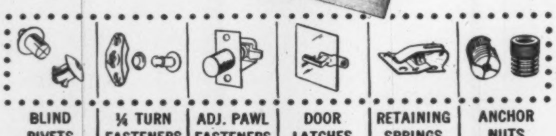
DIAMETERS	LENGTHS	NOMINAL GRIPS
1/8"	1/8" to 1/2"	1/32" to 13/32"
3/16"	1/4" to 3/4"	3/32" to 5/8"
1/4"	1/4" to 3/4"	3/32" to 5/8"



FREE RIVET FOLDER . . . Send for your free copy of "Southco Drive Rivets" Folder. Gives complete information on the application, installation, and specifications of aluminum and steel Drive Rivets. Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

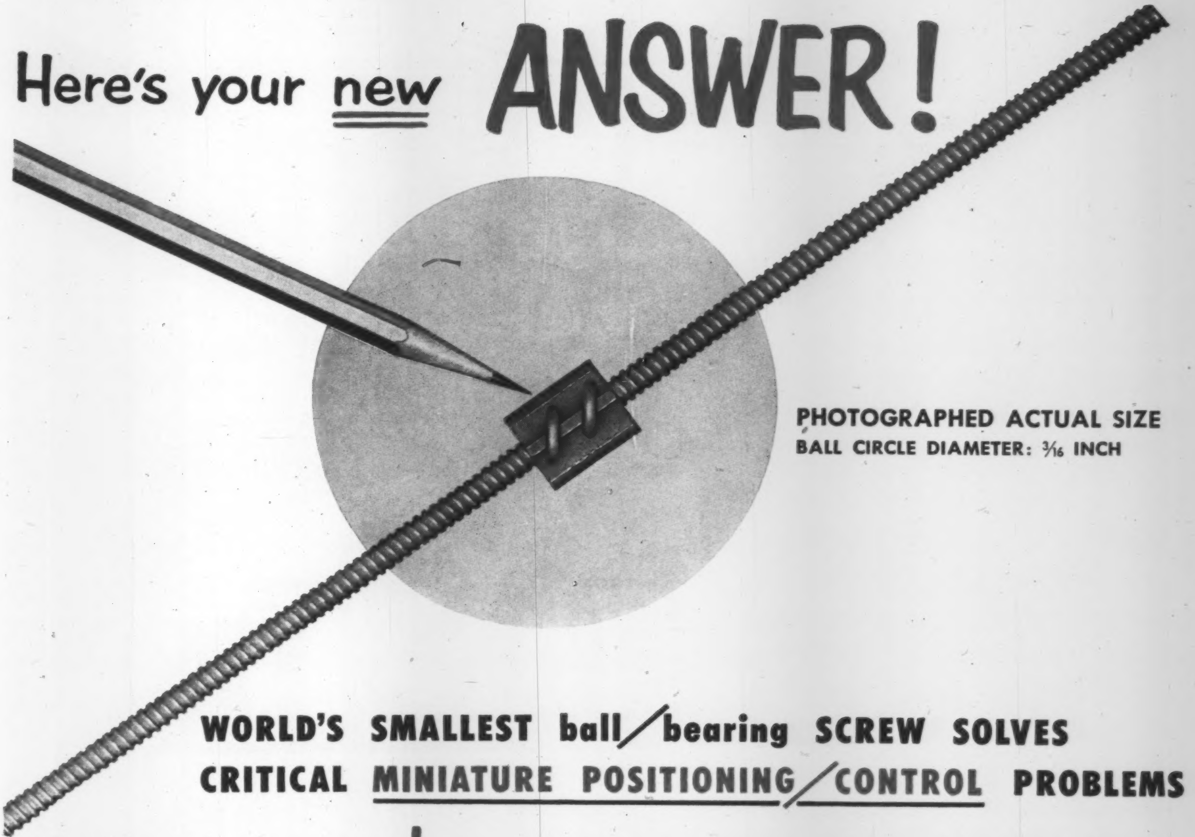
SOUTHCO / **LION** **FASTENERS**

©1957



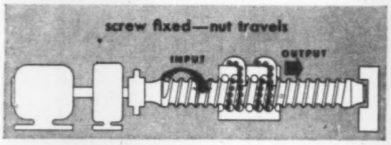
Circle 466 on Page 19

Here's your new ANSWER!

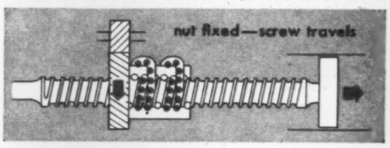


PHOTOGRAPHED ACTUAL SIZE
BALL CIRCLE DIAMETER: 3/16 INCH

WORLD'S SMALLEST ball/bearing SCREW SOLVES CRITICAL MINIATURE POSITIONING/CONTROL PROBLEMS



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.



SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.

An unprecedented achievement in minimum size and weight—maximum efficiency, dependability and service life for ultra-precise controls.

It's another first from Saginaw—and the possibilities it opens up for improved electrical and electronic controls are limited only by your imagination! Radar tuners, missile and rocket guidance and telemetering systems, automatic switchgear, electronic machinery controls are just a few of the applications where this new miniature Saginaw b/b Screw will solve critical positioning/control problems. *It's so compact and light,* you can save substantially on space and weight. *It's so efficient,* (over 90%) you can use much smaller motors and gear boxes. *It's so precise,* you can position components within .0005 inch per inch of travel. *It's so dependable,* you can rely on remarkably long service life even in adverse environments.

You will find our 1958 Engineering Data Book extremely helpful in planning applications, or experienced Saginaw engineers will gladly make specific recommendations without obligation.

LET SAGINAW'S EXPERIENCED ENGINEERS HELP SOLVE YOUR SPECIAL APPLICATION PROBLEMS . JUST WRITE OR PHONE US—NO OBLIGATION

Saginaw ball/bearing Screw

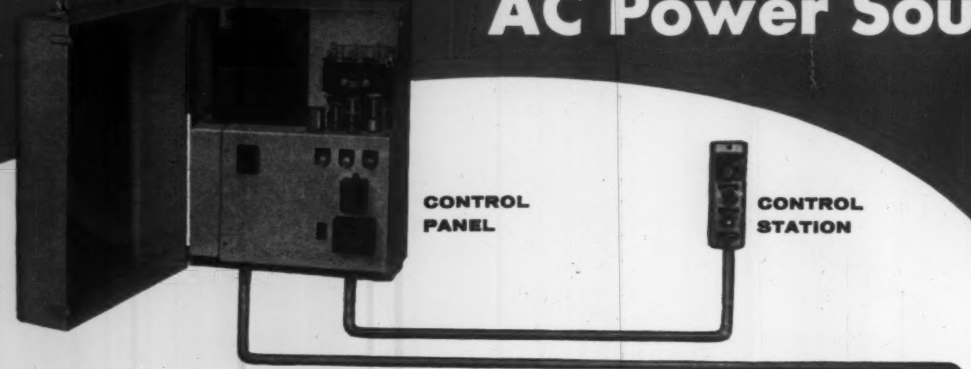
SAGINAW STEERING GEAR DIVISION • GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

Circle 467 on Page 19

EATON

DYNAMATIC®

Drive Package Provides Infinitely Adjustable Speeds from AC Power Source



The complete Dynamatic power package includes all components required to provide infinitely adjustable speeds from an alternating current power source. A Dynamatic Ajusto-Spede® or Dynaspede® Drive, with electronic control and pushbutton station, satisfies the requirements of almost any application where proper machine operation or material processing depends upon control of operating speeds.

The compact control panel may be remotely mounted to conserve valuable space on the driven machine. The pushbutton station at the operator's position puts vital controls conveniently at the operator's fingertips and requires a minimum of space.

Speeds are infinitely adjustable from 0 RPM to full output speed, and accurate speed regulation may be obtained from 100 RPM to full output speed.

Ajusto-Spede® Drives, available in ratings of 1/4 horsepower to 75 horsepower, are air-cooled. Dynaspede® Drives, rated from 3 to 75 horsepower, are liquid-cooled. Raise your productive efficiency with Dynamatic eddy-current units.

DYNAMATIC®
AJUSTO-SPEDE DRIVE

Send for Illustrated Literature Describing Dynamatic Adjustable Speed Drives

EATON

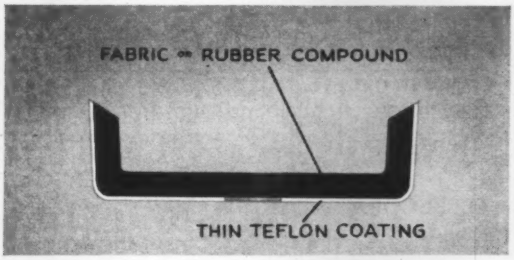
DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Circle 468 on Page 19

NEWEST OF THE GARLOCK 2,000

First Advance in Cup Design in 30 Years

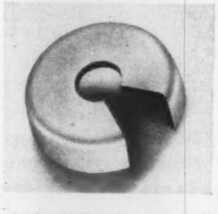
New Garlock TEFLON-Coated Cups



Cutaway shows how TEFLON coating is applied to outer surface of molded cup by special Garlock process. Coating becomes integral part of outer surface.

This exclusive Garlock development will substantially improve the operation of your hydraulic or pneumatic equipment.

TEFLON-coated cups reduce the breakaway torque required to operate cylinders; reduce running friction; will not stick to cylinder walls even after long periods of idleness. Completely eliminate "squealing." All this, of course, results in longer life, less downtime.

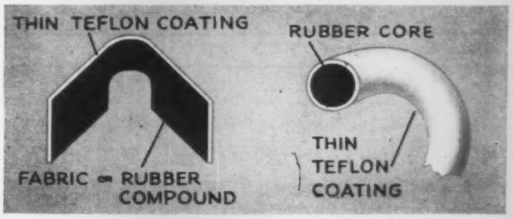


TEFLON, with its low coefficient of friction and anti-sticking characteristics, has for many years resisted the efforts of manufacturers to use it as a coating. The very anti-sticking qualities that make it desirable, also made it difficult to work with. Now Garlock has perfected a technique for coating molded cups with a thin layer of TEFLON. This coating becomes an integral part of the cup.

Most important, of course, TEFLON-coated cups are low in cost, only slightly higher than ordinary cups.

Get full information on this newest member of "the Garlock 2,000" . . . two thousand styles of packings, gaskets, and seals for every need. Call your local Garlock representative or write for Folder 145. You'll find information on other Garlock products in Sweet's Product Design File.

Other New Garlock TEFLON-Coated Products



To reduce friction and reduce downtime at low cost on applications using V-type packings or O-rings Garlock also furnishes TEFLON-coated CHEVRON* packing and TEFLON-coated O-rings. Both have the same exceptional anti-friction qualities of TEFLON-coated cups. These products are available in all the standard sizes. Write for CHEVRON folder AD-115; or O-Ring Folder AD-148.

*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada

GARLOCK

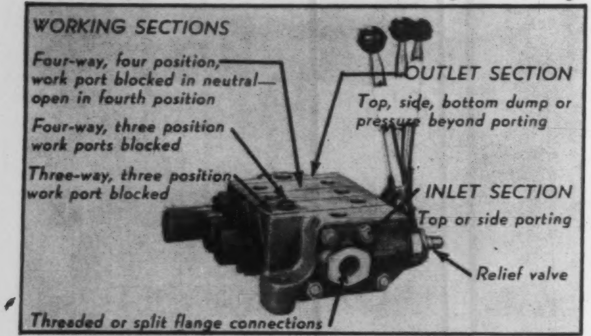
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Circle 469 on Page 19

DESIGNER'S CHECK LIST

VALVES — — CONTROL OIL HYDRAULIC POWER

flow performance as much as 20 gpm (05 series), 30 gpm (07 series) and 55 gpm (10 series) with back pressure ratings under 100 psi, non-constricted flow reduces pressure drop.


WORKING SECTIONS
Four-way, four position, work port blocked in neutral—open in fourth position
Four-way, three position work ports blocked
Three-way, three position work port blocked
OUTLET SECTION
Top, side, bottom dump or pressure beyond porting
INLET SECTION
Top or side porting
Relief valve
Threaded or split flange connections

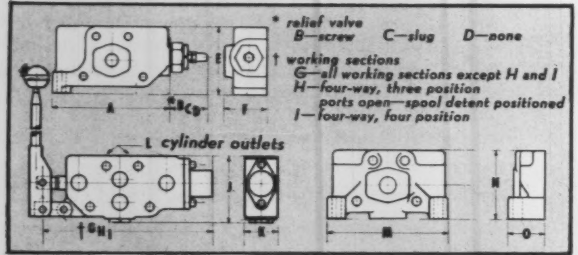
"Performance Rated" directional control valve consisting of inlet, three working and outlet sections assembled into leakproof unit. Any combination of working sections can be assembled in any sequence into a single space saving unit.

INTERNAL PRESSURE DROP (PSI)

in one four-way, three position working section when circuit is loaded —— work ports pressurized.

	FLOW (GPM)										
	5	10	15	20	25	30	35	40	45	50	55
05 SERIES	5.4	21.6	48.5	86.2							
07 SERIES			22.5	40.0	62.5	90.0					
10 SERIES							37.6	49.2	62.3	77.0	93.0

APPROXIMATE OVERALL DIMENSIONS (IN.)


A
B
C
D
E
F
G
H
I
J
K
L cylinder outlets
M
N
O

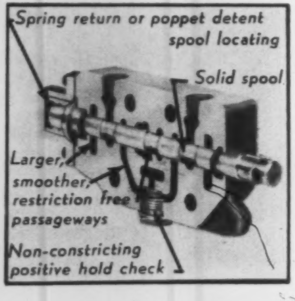
* relief valve
B—screw C—slug D—none
† working sections
G—all working sections except H and I
H—four-way, three position ports open—spool detent positioned
I—four-way, four position

SIZE	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
½″	7	2¼	1	⅛	4¹⁄₁₆	2½	10	12¹⁄₁₆	13	3⅞	2	½	7¼	4¹⁄₁₆	2¼
¾″	8	2¼	1	⅛	4 ⅞	2¾	11³⁄₁₆	13 ⅜	14³⁄₁₆	4¾	2½	¾	8¼	4 ⅞	2⅝
1″	10	3	1¼	⅛	6 ½	3½	14	17 ¼	17 ¾	6¼	3	1	10½	6 ½	3¼

OPERATING PRESSURE 2000 PSI
O-rings seal against leakage—dense hi-tensile castings absorb stress without distorting.

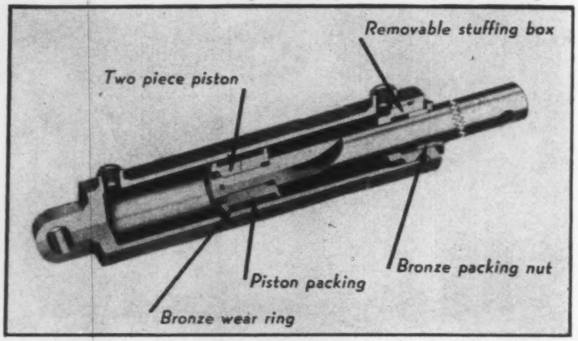
NO LOAD DROP
Positive hold check built into each working section prevents load drop or sag.

OVERLOAD RELIEF—PRESSURE CONTROL
Sensitive cartridge type pressure relief provides safety bypass protection against overload of hydraulic system


Spring return or poppet detent spool locating
Solid spool
Larger, smoother, restriction free passageways
Non-constricting positive hold check

CYLINDERS — UTILIZE OIL HYDRAULIC POWER

single acting, double acting, telescopic capacity up to 25 tons—stroke up to 45 inches operating pressure up to 1500 psi.


Removable stuffing box
Two piece piston
Bronze packing nut
Piston packing
Bronze wear ring

Double acting solid plunger cylinder fitted with two piece piston. Disassembly for easy inspection and replacement of piston or stuffing box packings is a simple field operation. Note there is no metal to metal contact between piston and cylinder.

DOUBLE ACTING

ROD. DIAMETER		1	1¼	1¼	1½	1½	2	2	2½	2½
CYLINDER O.D.		2½	2⅞	3	3⅞	4⅞	5⅞	6⅞	8	9¼
DISPLACEMENT	PUSH	.014	.017	.021	.036	.061	.094	.133	.179	.242
	PULL	.010	.012	.016	.028	.054	.080	.119	.158	.220
EFFECTIVE AREA	PUSH	3.1	4.0	4.9	8.3	14.2	21.6	30.7	41.3	55.9
	PULL	2.4	2.7	3.7	6.5	12.4	18.5	27.5	36.3	50.9

SINGLE ACTING

PLUNGER DIA.	1	1½	1¾	2	2½	2¾	3¾	4¾	5¾	6¾	7⅞
CYLINDER O.D.	1⅞	2⅜	2⅝	2⅞	3½	3⅞	4⅞	5⅞	6⅞	8	9¼
DISPL'CM'T	.003	.008	.010	.014	.021	.026	.048	.077	.112	.155	.210
EFF. AREA	0.8	1.8	2.4	3.1	4.9	5.9	11.0	17.7	26.0	35.8	48.7

TELESCOPIC

SLEEVE DIAMETER

SLEEVE NO.	CYLINDER O.D.				
	4⅞	5⅞	6⅞	8	9¼
1ST	3¾	4¾	5¾	6¾	7⅞
2ND	2¾	3¾	4¾	5¾	6¾
3RD		2¾	3¾	4¾	5¾
4TH			2¾	3¾	4¾
5TH				2¾	3¾

DISPLACEMENT

SLEEVE NO.	CYLINDER O.D.				
	4⅞	5⅞	6⅞	8	9¼
1ST					
2ND	.037	.062	.095	.133	.183
3RD		.050	.079	.115	.159
4TH			.066	.098	.139
5TH				.083	.121

Figures in tables shown in units as follows: diameter—inches, area—square inches capacity—pounds, pressure—lbs. per sq. in. displacement—gallons per inch of stroke

EFFECTIVE AREAS OF SLEEVES

SLEEVE DIAMETER	2¾	3¾	4¾	5¾	6¾	7⅞
EFFECTIVE AREA	5.9	11.0	17.7	26.0	35.8	48.7

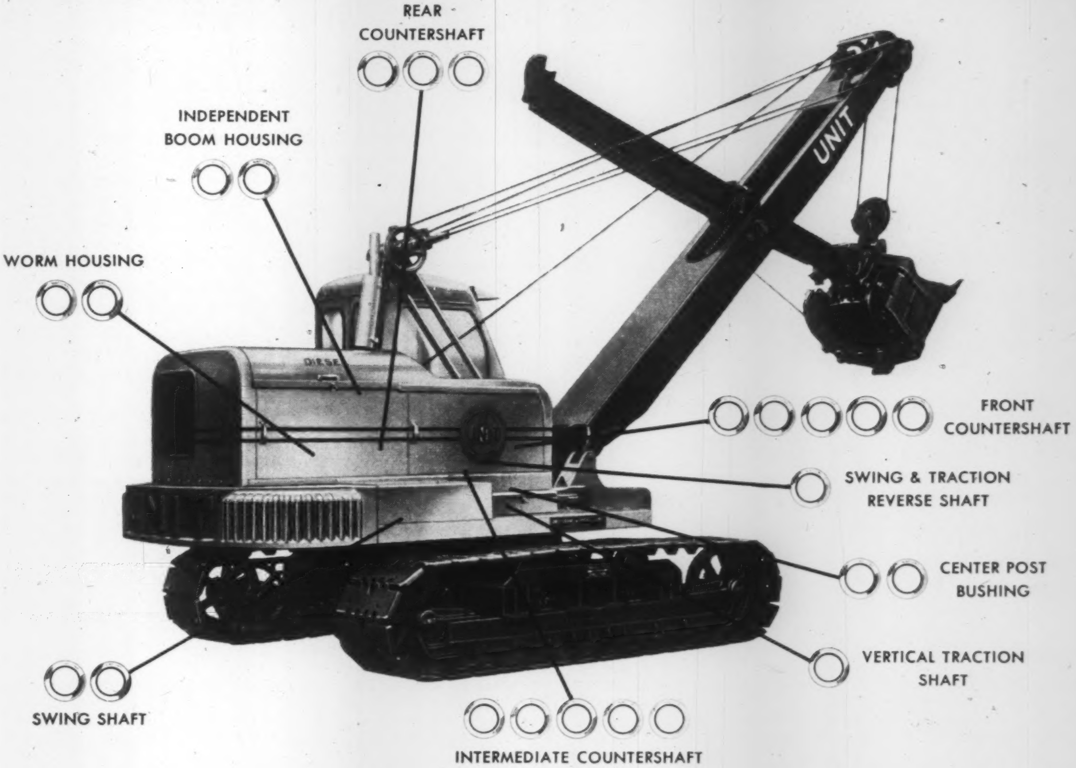
Cylinder capacity, neglecting friction loss, can be approximated by multiplying rod, plunger or sleeve effective area by operating pressure.

Commercial Shearing & Stamping Company

Dept. S-36, Youngstown, Ohio

COMMERCIAL
shearing & stamping

NATIONAL OIL SEAL LOGBOOK


REAR COUNTERSHAFT
INDEPENDENT BOOM HOUSING
WORM HOUSING
UNIT
FRONT COUNTERSHAFT
SWING & TRACTION REVERSE SHAFT
CENTER POST BUSHING
VERTICAL TRACTION SHAFT
SWING SHAFT
INTERMEDIATE COUNTERSHAFT

National Oil Seals used at key points throughout UNIT Crane & Shovel excavators

UNIT Model 1020 pictured above is a ¾ yard diesel excavator designed for maximum convenience and versatility in medium-duty applications. As in other UNIT excavators, National Oil Seals are installed at key points to retain lubricant, exclude dirt and water, and prolong life of bearings and assemblies.

In the UNIT 1020 Excavator, a total of 23 National Seals are employed in 9 basic subassemblies. These include front, rear and intermediate countershaft assemblies, swing traction reverse shaft, the turntable center pin assembly, vertical swing shaft, worm housing and traction shaft assemblies.

Grease seals used in the Model 1020 are of the National 50,000 series design, employing a spring-tensioned leather sealing member mounted inside a precision-made steel outer case. Shaft sizes range from 11/16″ in the intermediate countershaft assembly to 8″ on the turntable center pin. Similar use of National Seals is made in 11 other excavators offered by UNIT.

National Seals used in the UNIT Model 1020 are all of standard design; National offers over 2,500 different such seals or can design special seals for special requirements. Call your National Applications Engineer. He's listed in the Yellow Pages, under Oil Seals.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Downey and Redwood City, California

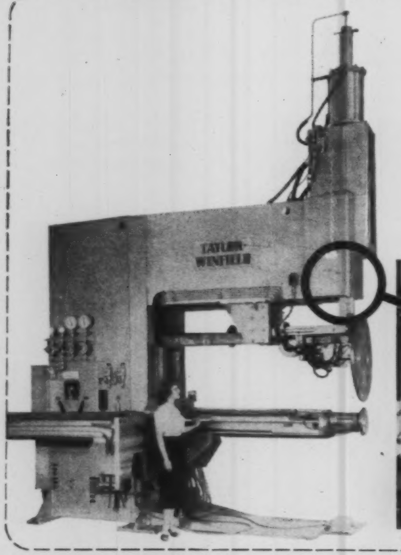
4956

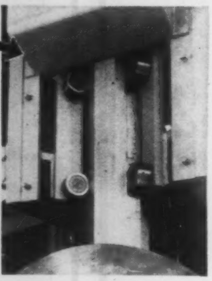
BEARING TIPS
by McGill

McGILL CAMROL®
bearings cost less to increase efficiency of cam follower, guide and support roller applications

Using CAMROL CF and CYR (cam yoke roller) bearings eliminates the inconvenience of obtaining and processing component parts for built up followers. It costs less to select the proper size CAMROL bearing from stock than machine and assemble loose bolts, bushings, bearings, and snap rings.

CAMROL bearings are engineered and precision built to carry heavier loads with greater accuracy and alignment. An extra heavy outer race with full roller complement on a flanged stud (or inner for CYR) offers high load and shock capacity. Smooth, dependable action with low starting friction is assured through longer machine life. Available sealed also.





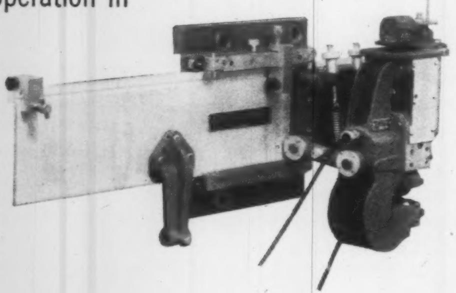
Improved performance, reduced friction and greater accuracy as ram guides in huge welder

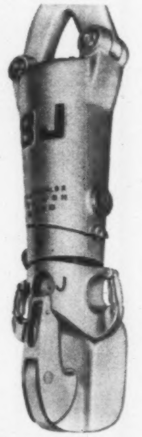
The long ram stroke and large diameter welding wheel impose severe requirements on the CAMROL equipped ram guiding device of this resistance seam welder manufactured by the TAYLOR-WINFIELD CORPORATION. The CAMROLS provide greater accuracy with less friction than was experienced with a round ram and bushing type bearing formerly used. Lubrication is simplified, maintenance reduced and performance is excellent.

The welder has a throat depth of 84″ and a 12″ vertical stroke of the upper ram carrying the large diameter welding wheel.

Ease of assembly and smooth operation in electrolimit continuous gage

PRATT & WHITNEY CO., INC., manufacturers of the ELECTROLIMIT CONTINUOUS GAGE shown here have cut costs through the elimination of built up followers requiring ball bearings, shafts, spacers and milling slots by using sealed CAMROL bearings. They are prelubricated and protected. The CAMROL bearings which travel along a vertical cross slide rail, provide smooth, easy action as the gage slides onto strip material running through the mill. No bearing replacement reported in over 10 years.





CAMROL® bearings take severe impact loads in hydraulic snubbing hooks

CAMROL CF bearings are used as hook positioner rollers in BRYON JACKSON HYDRAPLEX HOOKS. These heavy-duty (100-150 ton capacities) hooks are used in oil well drilling work. The hook positioner mechanism includes CAMROL cam followers that travel on a hardened cam track when the load is released to return the hook to its original position. The CAMROL bearings take severe impact loads in the thousands of pounds.

engineered electrical products

McGILL®

precision needle roller bearings

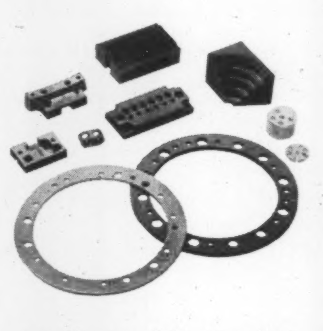
SEND FOR CATALOG No. 52-A

MULTIROL — GUIDEROL — CAMROL

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 472 on Page 19

A plane's best friend is Reliability



Aircraft parts of Synthane laminated plastics combine light weight, strength and electrical insulating properties.

Almost anyone who flies spells "Reliability" with a capital "R". Which is one reason why the aviation industry is a good customer for Synthane laminated plastics. There are other reasons.

Synthane is a material with many useful properties in combination. It's light in weight (half the weight of aluminum). It's an insulator with high dielectric strength, low dielectric losses, excellent insulation resistance. It's easily machined and resistant to chemicals. You'll go far to find one material with all these desirable characteristics.

But Synthane is more than a material. It is an investment in reliability. Quality control from the raw materials to the finished product assures you of uniformity and rigid compliance with your most exacting requirements.

Synthane is people. People who have grown up with our company and take pride in turning out a first-class job. People to whom promises of delivery mean something. People who are specialists in working with laminated plastics. In short, people you can count on. What does all this cost you? Little or no more than you are now paying for other plastic laminates.

If you are interested in a reliable source of laminated plastics, you might remember that after "R" for Reliability comes "S" for Synthane . . . and Service.

SYNTHANE
S

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

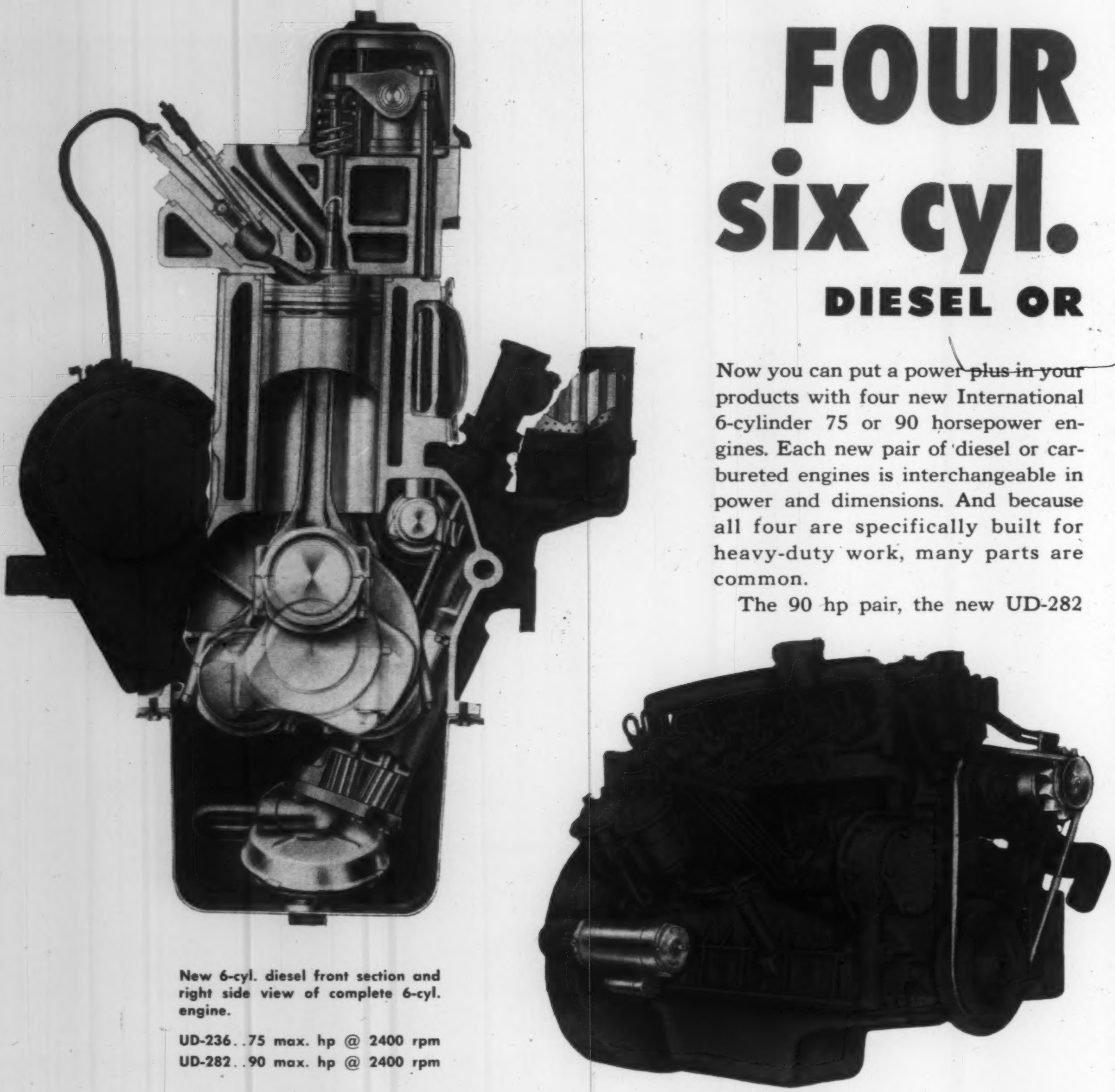
Circle 473 on Page 19

FOUR six cyl.

DIESEL OR

Now you can put a power ~~plus in your~~ products with four new International 6-cylinder 75 or 90 horsepower engines. Each new pair of diesel or carbureted engines is interchangeable in power and dimensions. And because all four are specifically built for heavy-duty work, many parts are common.

The 90 hp pair, the new UD-282



New 6-cyl. diesel front section and right side view of complete 6-cyl. engine.

UD-236..75 max. hp @ 2400 rpm
UD-282..90 max. hp @ 2400 rpm

HEAVY-DUTY ENGINE FEATURES FOR DEPENDABLE, LOW-COST PERFORMANCE

UD-236 and UD-282 Diesel Engines

- 17.6:1 compression ratio for compression ignition and minimum fuel consumption
- Simple accessible fuel injection system with automatic advance for best fuel economy
- Precombustion chambers for low firing pressures and clean burning of No. 2 diesel fuel under all loads and speeds
- Exhaust valve rotators and intake valve umbrella oil seals
- Easy 12-volt direct electric starting
- Pressure lubrication through full-flow filter and rifle drilled passages
- Deep I-block crankcase ribbed for extra strength and rigidity.
- Replaceable cylinder sleeves for low cost life extension
- Heat treated forged steel I-beam connecting rods
- Low friction aluminum-alloy dished top pistons
- Thoroughly sealed against life-robbing dust and dirt
- 6-cylinder smoothness in a complete package

UC-221 and UC-263 Carbureted Engines

- 7.2:1 compression ratio and large 18 mm spark plugs for top performance on regular gasoline
- Updraft carburetor and top outlet exhaust for high sustained power output with minimum heat interference
- Fully machined combustion chambers for uniform power from each of six cylinders
- Exhaust valve rotators and intake valve O-ring oil deflectors
- 12-volt starting and ignition system
- Pressure lubrication through full-flow filter and rifle drilled passages
- Deep I-block crankcase ribbed for extra strength and rigidity
- Replaceable cylinder sleeves for low cost life extension
- Heat treated forged steel I-beam connecting rods
- Low friction aluminum-alloy stepped-dome pistons
- Thoroughly sealed against life-robbing dust and dirt
- 6-cylinder smoothness in a complete package

NEW International 75-90 horsepower

GASOLINE INTERCHANGEABLE ENGINES

and UC-263, as well as the 75 hp UD-236 and UC-221, feature efficient, economical valve-in-head design, replaceable cylinder sleeves, thru-hardened counterbalanced crankshafts and gear-driven induction hardened camshafts for a new high in long life dependability.

The UD-282 and UD-236 are direct-start diesels with time-proven International pre-combustion chamber design. Use of a ¼″ larger bore in the diesels makes possible the same power as corresponding gasoline models with lower B.M.E.P. A glow plug for each pre-cup is regular equipment for easy starting in any weather.

Gear-driven mechanical governors on all engines provide excellent speed regulation. Rated load speeds to 2400 rpm are available to suit application requirements.

Installation in your products is simplified by six-cylinder built-in smoothness and availability of matched power unit components including air cleaner, base, radiator and enclosure.

For complete information on any of 22 International 4, 6, and V-8 engines, write International Construction Equipment Division, Melrose Park, Illinois.

Brief Specifications

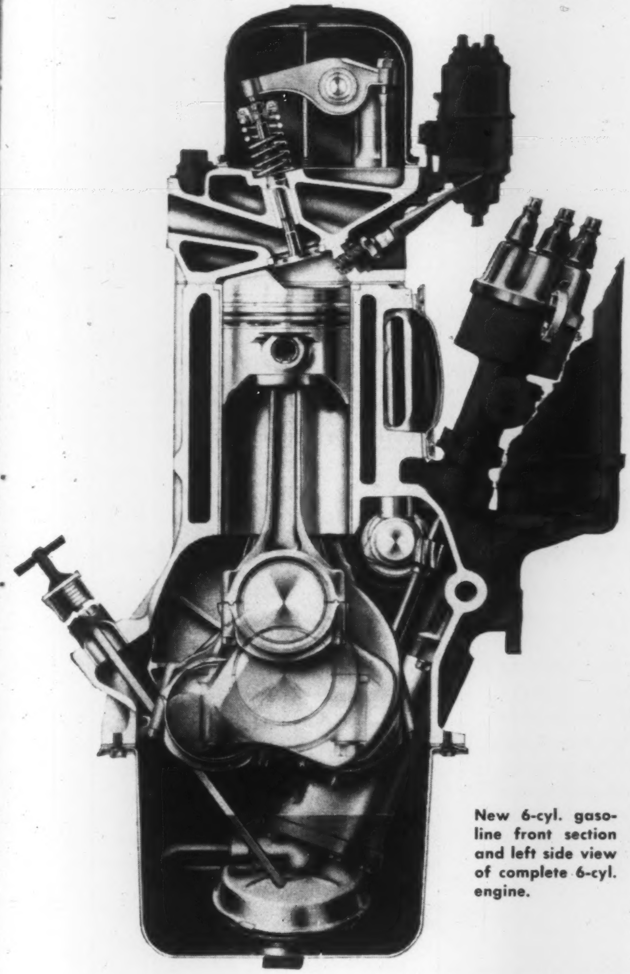
MODEL	UC-221	UD-236	UC-263	UD-282
Bore	$3\frac{9}{16}$″	$3\frac{11}{16}$″	$3\frac{9}{16}$″	$3\frac{11}{16}$″
Stroke	$3\frac{11}{16}$″	$3\frac{11}{16}$″	4.390″	4.390″
Displ. cu. in.	221	236	263	282
Max. hp @ 2400 rpm	75	75	90	90
@ 1800 rpm	61	61	72	72

Overall length of all engines with fan and No. 3 flywheel housing is $41\frac{3}{16}$″

International® Construction Equipment

International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.



New 6-cyl. gasoline front section and left side view of complete 6-cyl. engine.

UC-221 . . 75 max. hp @ 2400 rpm
UC-263 . . 90 max. hp @ 2400 rpm

Circle 474 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*

Texkote steel, made by Sun Steel Company, Chicago, Ill., is used on Admiral Slimline portable TV sets in pigskin tan and black leather finishes. Texkote finishes on steel or aluminum can be obtained in any color in a wide variety of textures. Plastisol is formulated by Bradley & Vrooman Company, Chicago, Ill. B.F.Goodrich Chemical Company provides the Geon polyvinyl material only.

Admiral TV set proves the case:

STEEL GETS NEW VERSATILITY WITH GEON COATING

THIS portable TV's case is actually made of steel. Yet it looks like leather. You can wash it. It resists scuffs and stains. It's an example of the versatility being added to steel and aluminum with coatings made from Geon polyvinyl materials.

Geon-coated metals can be formed, bent, punched, or even projection welded without damage to the coating. Products can be solid or multi-colored. Textures can match the beauty of wood, leather, fabrics or other materials.

The Geon coatings also offer superior abrasion, electrical and chemical resistance. It's another example of how versatile Geon can provide the key to a new or improved product. For more information, write Dept. LO-5, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

A TRADE MARK OF B. F. GOODRICH CHEMICAL COMPANY
Geon
Polyvinyl Materials
A DIVISION OF THE B. F. GOODRICH COMPANY

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B.F.Goodrich

GEON polyvinyl materials • HYCAR American rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

TOTAL COVERAGE

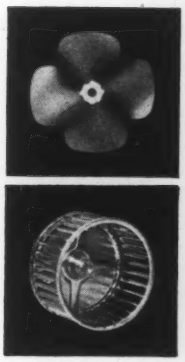
No matter which way the wind blows with your blower unit requirements—belt-driven, direct drive or radial-axial mixed flow—Torrington has the solution to your problems.

This means complete technical data and the proved-out performance rating on three lines of basic blower unit designs.

In addition to the standard direct drive units and the already famous VariBasic belt driven series, latest and most spectacular addition is the exclusive Radiax unit, combining the optimum performance characteristics of both radial and axial flow techniques.

The result is FULL COVERAGE—the best "problem insurance" you could have.

Talk to Torrington!



THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

Circle 476 on Page 19

FOR *Precision Parts with Economy*

ZINC DIE CASTINGS ARE BEST

CLEMSON PRECISION LAWN MOWERS have proved through twenty years of experience the best way to build strong, durable machines requiring complex precision parts at low cost.

BY DESIGNING FOR ZAMAK ZINC DIE CASTING ALLOYS, CLEMSON ACHIEVED:

- **. . . ACCURACY AND UNIFORMITY OF PARTS**
- **. . . LOWER ASSEMBLY COSTS**
- **. . . ELIMINATION OF EXTRA PARTS**
- **. . . A SMOOTH OPERATING, PROPERLY BUILT MACHINE**

HORSE HEAD SPECIAL ZINC AND ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

160 Front Street · New York 38, N. Y.

HORSE HEAD PRODUCTS ®

Circle 477 on Page 19

MACHINE DESIGN
September 4, 1958

Blasts, Hoots, Yawns

CREATIVITY is a funny thing. First, we all modestly admit that we have it. Other people—bosses and psychologists—choose to recognize different degrees and kinds of it. It's fair game for debate by anyone. But what do we mean by creativity?

Let's look at it only in relation to one's job. Let's define creativity as the capacity to add something to the job by way of idea, invention, unique problem solving.

We all hope that our brain children will be accepted by others. And we fear, consciously or otherwise, that they will not be.

Then, this is the riddle: How can I exploit talents and ideas I know I can bring to the job, without suffering the blasts, hoots, or yawns of the other guy, whether boss or colleague?

Take a new man. Bubbling with new ideas, he all too often encounters ill-concealed ridicule from his associates or condescending explanation from his superiors. This is the crucial fork in the road. Does he give up? Does he persist?

The man who gives up, but stays on the job, chooses a humdrum life. Playing it safe can leave one feeling secure but vaguely discontent about earlier, bold aspirations for the future—which too many times is today.

The man who *blindly* persists is ill-fated. He becomes a problem, a "character," inviting exasperation if not outright rejection. He claims the organization is restricting, other people unsympathetic. He quits to find other walls to bang his head against—and perhaps he finds softer ones.

There's a lot of space between these two extremes.

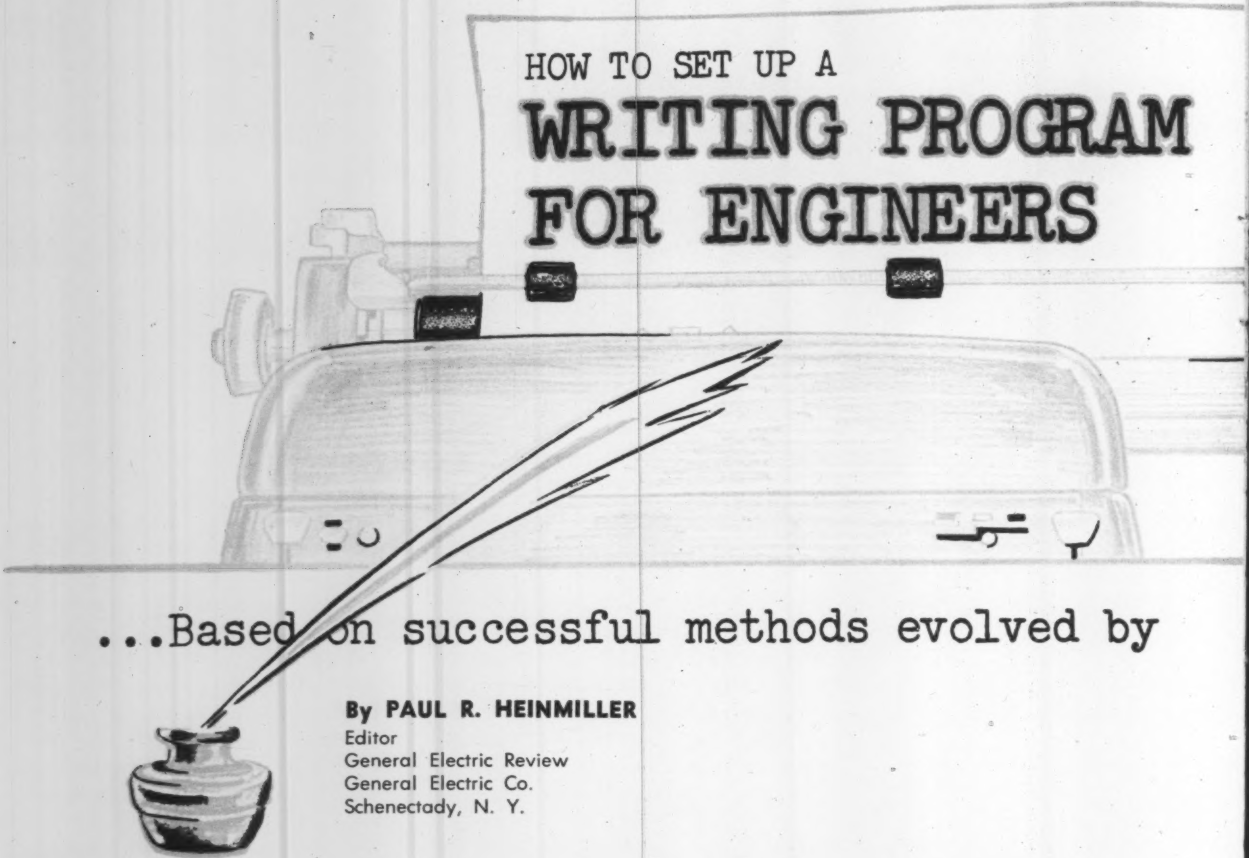
Persistence is essential, if it's aimed right. With time comes experience: The accumulated knowledge and skill in working with things, people, organization—and ideas.

Creativity and enthusiasm, oriented by experience, find directions that are meaningful to the total effort. Rebuffs diminish—at least, they don't hurt as much. Instead of being confined by the framework of his job, a man finds that he is able to modify and expand it—as he himself grows within it.

Ben Hummel

ASSOCIATE MANAGING EDITOR

HOW TO SET UP A WRITING PROGRAM FOR ENGINEERS



...Based on successful methods evolved by

By PAUL R. HEINMILLER
Editor
General Electric Review
General Electric Co.
Schenectady, N. Y.

ALTHOUGH most companies are in favor of having their engineers write, only a small percentage of engineers actually do any writing. Engineers who write can encourage their associates to become active. Engineering-department managements can do much to increase the writing activity among their engineers. The typical engineer need only be provided with a reason, a subject, and a little help to make him an active writer.

Engineering management at General Electric has been unusually successful in encouraging their engineers to take an active part in presenting technical papers and writing articles. A number of ideas that have been found valuable in getting General Electric engineers to write are given in this article. The majority of these ideas can be employed to good advantage by any firm, large or small.

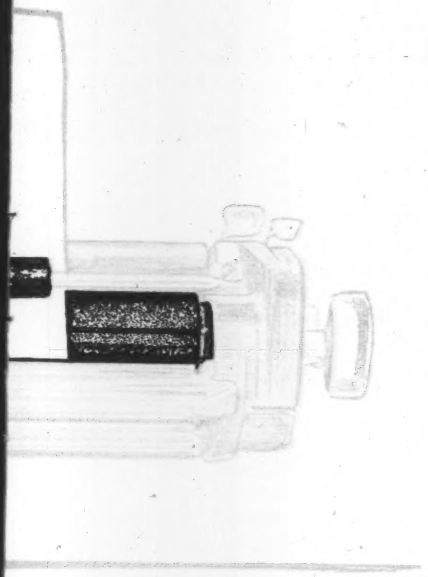
The Right Climate Is Needed: Engineers are avid readers—and are interested in writing. The number of engineers who are writing can be greatly increased if the climate within the department is favorable. Since engineering management is the source of the policies, reactions, comments, and encouragement that make up a favorable climate, management can expect to be largely responsible for the level of writing activity. To increase the writing output, members of engineering management must firmly believe in the benefits of writing and be able to convey their own enthusiasm convincingly.

Enthusiasm Can Be Built: Talks can be scheduled during regular engineering meetings to show management's favorable reactions to writing. Potential authors can be encouraged during these meetings and during private conversations. If some of the engineers are already writing, a periodical report that shows the output of each engineering group can be used to create interest and a spirit of competition.

1ST
ANNUAL
AWARD

Personnel records should be maintained, showing the number of published articles by each engineer over the past few years. An annual award should be considered—perhaps a desk set, suitably engraved—for the best paper of the year.

Sell the Idea: The benefits of writing articles—both to the engineers themselves and to the company—must be emphasized constantly. Familiar benefits include additional prestige and recognition



General Electric Co.

that the author receives from his associates in professional circles, his office associates, plant employees, neighbors in the community, and members of his own family.

The value of engineering developments is limited by keeping this knowledge within the company. Knowledge, spread throughout industry via the medium of articles and lectures, provides broad benefits. While any one company today contributes only a small part of the world's research and development work, each company benefits greatly from the policy of free publication followed in most countries. A company should publish promptly and freely, wherever it can without jeopardizing the company or others concerned.

Dr. Guy Suits, General Electric vice president and director of research, in a statement about writing of articles by research scientists, said, "The sponsor of research must remember that modern technical progress—including his own—is built on prior work by scientists the world over. Recognition by the sponsor of an obligation to contribute to the common pool of knowledge, upon which future progress will be built, can be justified on purely selfish grounds alone."

Leadership Must Be Provided: The engineering manager should be an active author himself—one

Subjects for Articles

The list of subjects for signed articles is as unlimited as the breadth of reader interest in the many business, trade, and technical magazines. Selection of a subject can be simplified by considering what will be of value to the company for commercial, engineering, or other reasons. After selection of general subject, determine what aspect is most worthwhile, newsworthy, and interesting.

An author should write about work with which he is most familiar and in an area where he can make an original contribution. A partial list of general subjects about which articles or society speeches might be written is:

1. Engineering description of a newsworthy product, design, or process.
2. How to select equipment for specific uses or industries.
3. Why, when, where, and how to apply a product or process.
4. How to install it for long, trouble-free operation.
5. How to maintain equipment. Frequently, articles can be directed to specific industries or can cover particular products across all industry.
6. Any first—for instance, the first application of a specific product in a certain industry.
7. Thought-provoking articles—"How to Get Most Value from Design," "When is Ultrasonic Cleaning Uneconomical?", or "Should a Single Material-Specification System Be Established?"
8. "Trend" articles. If a company is a major factor in any industry and the frequent originator of new ideas in fields such as engineering, manufacturing, or marketing, company representatives can often present reviews of past accomplishments and authoritative forecasts of future developments.
9. Problem-solution articles. Solving an interesting electrical or mechanical problem can be helpful to readers in many other areas.
10. Interesting manufacturing techniques. Tempered by sound business judgment, an article of this type can aid company progress, and implies the quality being built into the products.
11. Research, test, and development findings.
12. How things are done. Materials handling, drafting, plant layout, employee training, management problems, safety, purchasing, accounting, housekeeping, sales promotion, and many more areas make excellent subjects for articles.
13. Economic problems. Whenever it is possible to tell someone how to do something less expensively and yet efficiently, there is an interested audience.

Setting Up an Articles Committee

The Jet Engine and Production Engine Departments of General Electric, Evendale, Ohio, organized a joint Signed Articles and Speakers Committee. Their planning steps offer a guide to setting up a similar operation in any organization . . .

Formation of Committee: First, objectives were set forth for the proposed committee:

1. Increase the amount and quality of published material in the business, trade, and technical press, and at professional-society meetings, by a plan for signed articles and speeches.
2. Evaluate article and speech subjects to select those of greatest benefit to management and marketing objectives and to suggest most qualified authors.
3. Establish the department managers and specialists as recognized authorities in their technical and professional fields through planned signed articles and speeches.

A letter was then sent by the Promotion and Publicity Subsection of Marketing to general managers, who sent letters to their section managers to acquaint them with the plans, urge them to co-operate, and asking them to appoint a section representative. At the first meeting of the Committee, the general managers gave their oral endorsement of the program. A Communications Campaign was planned. This was publicized internally by an article placed in the plant newspaper and the word was spread by section representatives through staff meetings, letters, and personal contact.

Functions of Committee: The chairman was chosen from the Promotion and Publicity Subsection of Marketing. This was a logical choice, because Promotion and Publicity services both departments for other promotional activities. Specific duties of the chairman include: 1. Conducting committee meetings. 2. Encouraging and assisting in preparation of articles for national magazines, speeches for trade associations, and papers for technical societies. 3. Working on outlines with the authors. 4. Obtaining company approval on article and speech material, publicizing results of the committee's work, and preparing reports.

Committee Members consist of one man from each section, such as engineering, manufacturing, and marketing. Each man is responsible for helping to find potential authors and speakers, assisting them in preparation of material, and giving them information on procedures to follow. Committee members attend quarterly meetings, although when the committee was getting started, meetings were more frequent.

who can continually demonstrate the advantages to be gained from writing to the men reporting to him. But, rather than always being the writer, the alert manager will constantly seek opportunities to give his men the chance to write. This, of course, is one of the basic principles of management by persuasion, rather than command. Although the manager may suggest certain subject areas and convince an engineer to write in those areas, the engineer must write because he wants to.

Writing Should Be Part of the Job: Managers in many General Electric engineering sections look upon writing as an integral part of an engineer's job. Frequently, this concept is included in the engineer's "Position Guide" or "Job Description." Writing should be a definite factor in management's appraisal of an engineer's performance on the job. Then, the engineer can expect to find his writing performance reflected in his rating—and ultimately in his pay schedule.

Quota Systems Are Useful: Although some engineering managers frown upon establishment of a quota system to determine number of articles expected per year from an engineering section, others use it successfully. One manager reports that the quota method ". . . has more power than any other I know of because it is a reasonably easy method of expediting and controlling the results." However, he has never established a quota for individual engineers; the quota is set by product lines. Different product lines justify different numbers of articles per year, depending on either the newness of the product or rate of changes in technology.

Participation in Technical Societies: It is surprising the amount of inducement to write articles that can be focused on an engineer by his professional contacts in technical societies. One engineering manager in Schenectady said, "Our application engineers in the paper industry belong to the Technical Association of the Pulp and Paper Industries. They are expected to belong to this association. To keep up with their work, they attend meetings and serve on various committees of this association.

Procedures for Submitting Articles: A definite procedure was established for handling the article from conception to finish.

1. Author discusses outline with committee member and/or chairman.
2. Author writes outline and submits three copies to chairman—sometimes via committee member.
3. Chairman checks outline. If satisfactory, he sends two copies to News Bureau and retains one in his files.
4. News Bureau representative, taking into consideration the author and chairman's recommendations, submits outline to a magazine for acceptance. If necessary, three magazines are approached. If the third also rejects the outline, the project ends. Very few are refused, however, and usually the first magazine accepts.
5. After acceptance, chairman requests author to complete article in six weeks—unless magazine gives another deadline.
6. Five copies of completed article and photographs—ten copies if a Washington security review is necessary—are sent to the chairman.
7. Article is reviewed by legal and patent sections, author's supervisor, and by Promotion and Publicity unit. If changes are necessary, the article is retyped and resubmitted to the chairman.
8. Two copies of article and photographs are sent to News Bureau representative. He, in turn, sends material to magazine for publication.

Procedures For Submitting Speeches and Papers: Basically, this is similar to the procedure for handling articles.

1. Usually, when Promotion and Publicity is aware of openings for speakers or papers at trade associations or technical societies, potential topics and speakers are solicited. This information is sent to the organization for acceptance.
2. After acceptance of an idea, an abstract or outline is normally necessary by a specified date. Speaker submits abstract to the chairman, who forwards it to Promotion and Publicity unit for review.
3. Abstract is sent to association or society.
4. Speaker completes his speech or paper within a time schedule and submits five copies —ten copies if a security review is necessary—to chairman who forwards it for approval to legal and patent sections, speaker's supervisor, and to Promotion and Publicity unit.
5. After approvals, speech is given by speaker or, in the case of national-society papers, is sent to society for preprinting before being presented.

By circumstances, they are almost forced to write and deliver papers before these associations. And, they consider it an honor to do so."

Establishment of an Articles Committee: Composed of representatives from engineering, manufacturing, and marketing, such a committee has proved valuable in many of our departments. For operating efficiency, a man with some management rank, or with a degree of authority delegated to him by a manager, should head the committee. Remainder of the group consists of six or eight men, depending on the size of the operating department.

Members of the committee must be reasonably familiar with the essence of a technical article, its value to the company, necessity of meeting deadlines, integrity of editors, and a knowledge of the techniques of getting an article published.

Easing the Author's Work: A central source for services should be provided, where engineers can get writing guides for specific magazines, professional help in preparing photographs and art work, assistance in obtaining approvals for articles, and any other guidance that will make his writing task easier. At first, an engineer may feel unfamiliar with the problems in writing. But, when offered guidance and assistance by someone in whom he has confidence as a capable specialist in the writing field, he learns to approach the writing assignment without reluctance.

The best approach for selling a story to a magazine is to present the editors with an outline. This is far superior to putting together a finished article and then hoping the editors will buy it. The outline is valuable to the writer because it: 1. Aids in organizing a logical sequence for the material. 2. Assures completeness. 3. Whets his interest in the assignment. 4. Facilitates placing the finished article. 5. Removes doubt as to the article's acceptance. A frequent question is, "What shall I write about?" The Articles Committee must have suggestions ready.

Typing, drafting, photographic, and editorial services will be of great value to the author many times between initial conception of article and its publication. A central service group can help engineers to become authors by:

1. Scheduling the article far enough in advance to give plenty of preparation time
2. Establishing a reminder system that will alert him periodically
3. Reviewing the article with him from the standpoint of requirements and practices of the specific magazine
4. Planning, if possible, a conference between author and a member of magazine's editorial staff

Review of articles by legal counsel is important. There are complicated legal problems connected with statements concerning patents, mention of individuals or companies, competition, security, and labor practices.

Members of the company's news bureau or public-relations staff are familiar with many technical magazines. They can tell which magazines carry the prestige in specific fields, they know which magazines pay—and the few that don't—and how much they pay. Members of the news bureau can also be helpful in arranging conferences between authors and editors of various publications.

Making Use of the Results: Reprints of signed articles appearing in magazines cost little. A supply should be on hand for authors to send to their professional associates, within and outside the company. The marketing organization will often regard article reprints as valuable sales-promotion tools for distribution to key customers.

Many signed articles generate inquiries. These should be referred directly to the author. This will give him added recognition of the value of his work and give him the opportunity to become known by other authorities in his field.

Reprint from
by
John
Doe

The article can be merchandised further by having a news release sent to the employee newspaper and to newspapers in the author's community, stating that engineer John Doe had an article published in a certain magazine. This publicity gives him additional prestige in the eyes of his professional associates, others in the company, friends in his community, and his family.

Tips and Techniques

Fractional Exponential Equations

An easy-to-remember method of solving fractional exponential equations, of the form $x = n^u$, where n and u are fractions, makes use of logarithms.

Express the righthand member of the equation as the reciprocal of n and apply a negative sign to the exponent.

$$x = \frac{1^{-u}}{n}$$

Take the log of both sides of the equation.

$$\log x = -u\left(\log \frac{1}{n}\right)$$

Convert the righthand member to standard form, with positive characteristic and mantissa, by adding and subtracting 10 to the value of the righthand member.

$$\log x = \left[10 - \left(u \log \frac{1}{n}\right)\right] - 10$$

Look up the antilog in log tables.

For example, find the value of x for $x = 0.500^{0.275}$. This equation can be expressed as $x = (\frac{1}{2})^{0.275}$ or $x = 2^{-0.275}$. Taking the log of both sides of the equation gives, $\log x = (-0.275)\ (\log 2.000) = -0.275\ (0.30103) = -0.08278$.

By adding and subtracting 10 from the right side of the equation, $\log x = (10 - 0.08278) - 10 = 9.91722 - 10$.

Looking up the antilog yields $x = 0.82644$.—Frederic T. Churchill, *designer, Ford Motor Co., Livonia, Mich.*

Area and Volume of Polygonal Shapes

Here are two formulas which can be used in the solution of regular polygonal shapes.

Area of Regular Polygon: When the number of sides N and the length of one side S are known, the area is given by

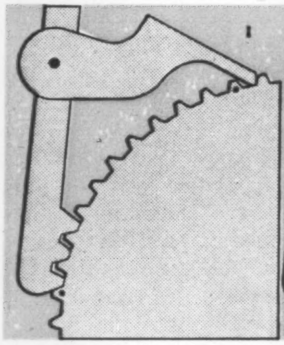
$$A = \frac{NS^2}{4} \tan\left(\frac{90(N-2)}{N}\right)$$

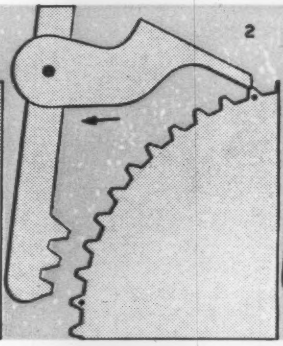
Volume of Regular Frustrum: The volume can be obtained from

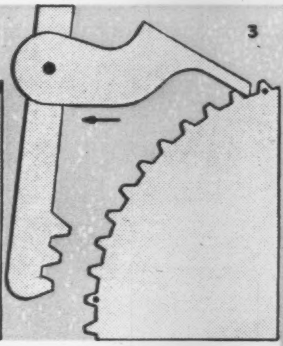
$$V = \frac{h}{12} \tan\left[\frac{90(N-2)}{N}\right]\left[S(S+s) + s^2\right]$$

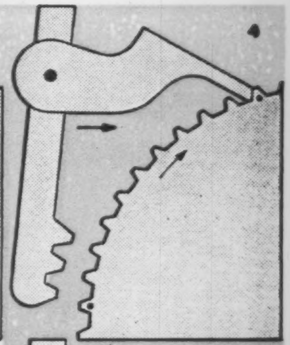
where h = height; N = number of sides; and s and S = lengths of top and bottom sides.—J. J. Milligan, *Toledo, Ohio.*

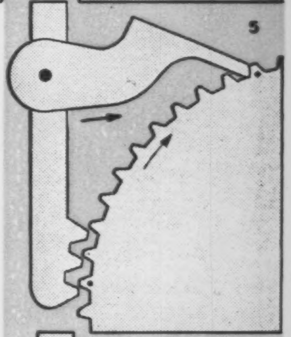
scanning the field for *ideas*

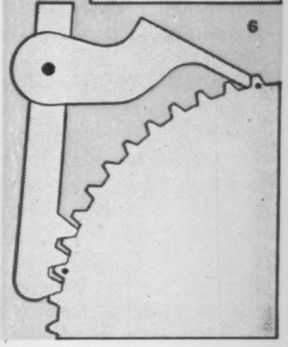






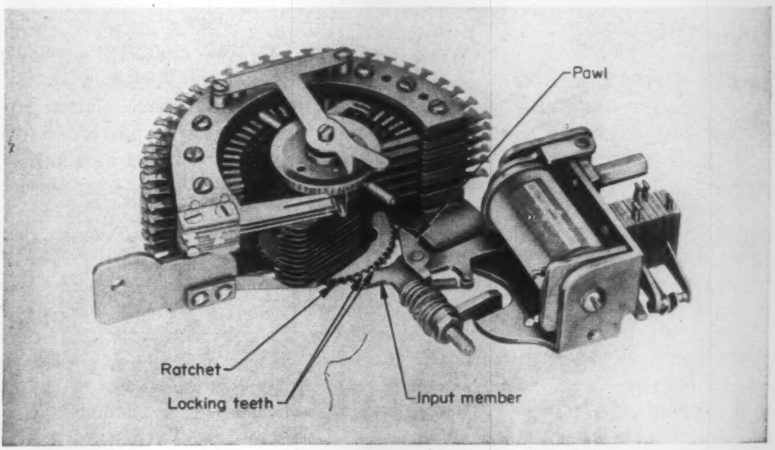


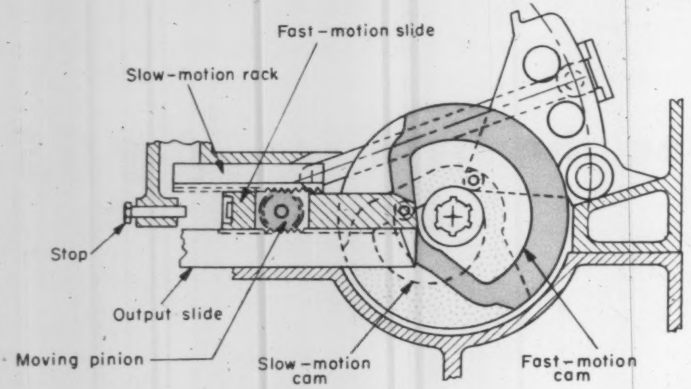




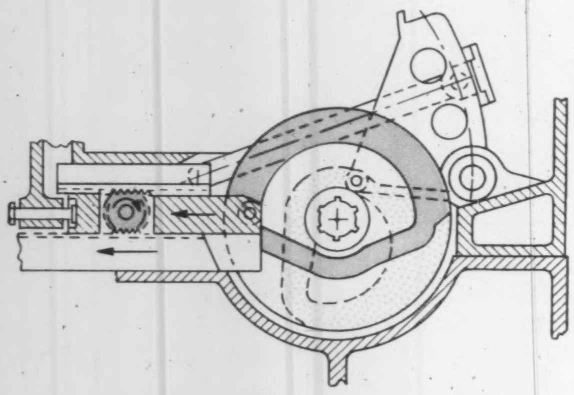
Stopping teeth on one member of a ratchet-and-pawl mechanism prevent overtravel of ratchet during indexing and assure accurate stepping action without backlash. In a design for a stepping switch, rotation of the ratchet is caused by oscillation of an input member, upon which the pawl is mounted. The end of the input member has teeth which engage the teeth on the ratchet to lock it against rotation.

Indexing is accomplished by moving the input member, carrying the locking teeth and the pawl away from the ratchet and then back. On the return stroke, the pawl advances the ratchet one space, just before the locking teeth engage the ratchet to prevent overtravel. The design was developed by Automatic Electric Co.

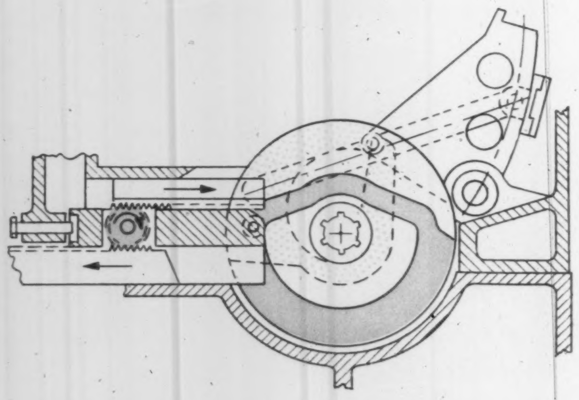




Rest Position



Fast-Motion Stroke Completed

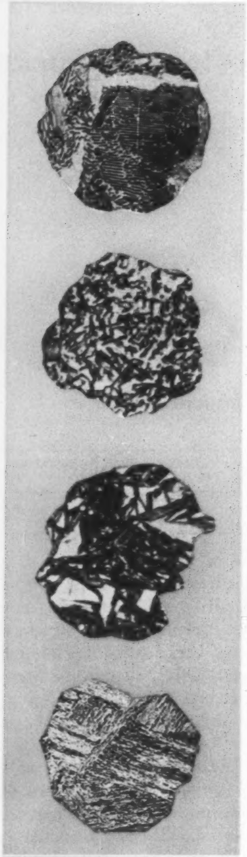


Slow Motion Stroke Completed

Compound-motion mechanism utilizes moving pinion in a dual-rack assembly to combine action of two independent cam-and-follower systems. Two face-track cams are mounted on a common shaft. The fast-motion-cam follower is mounted in the end of a slide that carries a pinion. The slow-motion-cam follower is mounted on a linkage that drives a sliding rack which engages the top of the pinion. The bottom of the pinion engages a rack on an output slide. During the fast-motion portion of the cycle, the slow-motion cam is on dwell and its sliding rack is stationary. Rotation of the fast-motion cam forces its slide to roll the pinion past the rack of the other cam. The resultant of the linear-rotary pinion movement is transmitted to the output slide with a 2:1 multiplication.

At the end of this movement, the fast-motion cam dwells and the slow-motion cam, through the linkage, causes its sliding rack to move. This movement is transmitted through the pinion to the output slide on a 1:1 ratio.

At the end of the slow-motion advance, both cam followers drop back to rest at the same time, imparting a high-velocity motion to the output slide. The design is employed in the end-tool actuating mechanism of a Warner & Swasey Co. multiple-spindle automatic.



Need ultrahigh strength?
Working at low temperatures?
Using large sections?

Requirements for exceptional service properties in an alloy steel can give designers and metallurgists headaches. "Cookbook" selection procedures are not possible, and each case must be handled individually. One logical approach is to start at metallurgical fundamentals—microstructure, hardenability, and alloy composition—and select a steel and heat treatment procedure tailored to the job. Following the routes described in this article, the engineer and metallurgist must work together to develop . . .

High-Performance Steels

By EDWARD A. LORIA
Staff Metallurgist
Crucible Steel Co. of America
Pittsburgh, Pa.

MICROSTRUCTURE is the major factor governing the properties of steel. If the designer knows the mechanical properties required of a steel, the first consideration is the choice of a suitable microstructure to achieve these requirements. Tempered martensite, bainite, and pearlite are the three basic structures in alloy steels. Quantitative relationships between these microstructures and properties are being developed. Such studies show that steel of a certain carbon content and of a certain microstructure will produce certain desired properties that can be correlated with service performance.

Optimum properties are obtained by using a steel of sufficient hardenability to assure that it will be fully hardened on the quench, then subsequently tempering the steel to obtain the strength level required for a particular application. Tempered martensite would be the ideal structure, for it represents the best combination of strength and toughness, as shown in Fig. 1, which compares tensile and impact properties of an alloy steel when heat treated to a particular microstructure.

Tensile strength of ductile steels is primarily a function of carbon content and, therefore, a function of hardness. This fact is well established for a range extending to a hardness of Rockwell C 42 and a strength of 200,000 psi. At higher strength levels, this relation is linear, as shown by the data for 4340 steel heat treated to 240,000 to 300,000 psi, Fig. 2. In this new critical area the proper analysis must be selected to provide adequate ductility when the steel is so hard. This can only be done if the composition lends itself to a tempering treatment which conditions the martensite properly.

Which Microstructure?: Properties of steels with bainitic or pearlitic microstructures (with the exception of fine bainite formed at temperatures near the martensite transformation) are inferior to those of tempered martensite steels. The bainites, as a class, are both harder and tougher than the pearlites. There are, however, wide variations in properties within each type. Lower or fine bainite is much harder and tougher than upper or coarse bainite, Fig. 3, and has a lower transition temperature.

Fine pearlite is markedly stronger and, at the same

Fig. 1—How Microstructure

One outstanding advantage of steel as an engineering material is the ease with which its properties can be controlled or changed by heat treatment. These properties are primarily controlled by two constituents of steel—iron (ferrite), and iron carbide (cementite)—and their amounts and distribution. The resulting microstructure is described as austenite, pearlite, bainite, or martensite.

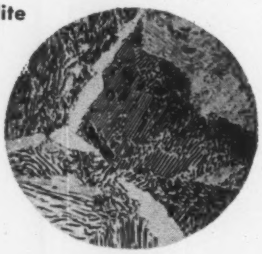
Objective of heat treatment is to achieve a combination of high strength and toughness by transforming the steel into a desirable microstructure of tempered martensite or lower bainite. Alloying elements help control this microstructure. Hardenability tests, like the Jominy end-quench test, help tell how deep a piece can be hardened, or the size piece which can be through-hardened under given cooling conditions.

Properties are for a 0.25 C, 2.0 Cr, 0.5 Mo steel as reported by Heger, Hodge, and Marshall (Ref. 1). Ductility-transition temperature was determined at the middle of the data-scatter band from keyhole-notched Charpy impact specimens tested at an energy level of 10 to 15 ft-lb.

Austenite

When a piece of steel is heated above the critical temperature (1300 F), the ferrite and cementite react with one another to form austenite. Austenite is not ordinarily present in steel after it has been cooled. But coarseness of the ferrite and pearlite in the cooled steel reflects grain size of the austenite prior to its transformation, and the properties of the product are profoundly influenced by its grain size.

Pearlite



Pearlite with proeutectoid ferrite

	Yld Str (psi)	Ten Str (psi)	Elong (% in 1")	Red Area (%)	Trans Temp (F)
Coarse	46,900	68,700	34.0	68.5	+28
Fine	57,500	92,500	27.0	71.5	—30

When a plain carbon steel of about 0.80 per cent carbon (eutectoid percentage) is cooled slowly from the temperature at which austenite is formed, all of the ferrite and cementite precipitate together in a characteristic pearlite structure. At carbon contents below 0.80 per cent, excess ferrite separates out at the grain boundaries. This structure is known as hypoeutectoid or proeutectoid ferrite.

With more rapid cooling, this transformation to pearlite does not occur until a lower temperature is reached. The faster the cooling rate, the lower the temperature at which transformation occurs. The ferrite-carbide structure formed varies markedly with the temperature of transformation, and properties are found to vary correspondingly. Lamellar (platelike) pearlite is found from 1300 to 1000 F. The thin "plates" become finer, and hardness increases as the transformation temperature goes down.

time, more ductile and less notch-sensitive than coarse pearlite. However, in hypoeutectoid steels, this general relationship can be modified by the presence of proeutectoid ferrite. Ferrite grain size is an important factor in notch toughness, and amount and form of ferrite will also change with alloy content and cooling rate. These factors must be reckoned with, particularly in the lower carbon steels. They also complicate the effort to arrive at a simple correlation between microstructure and mechanical properties.

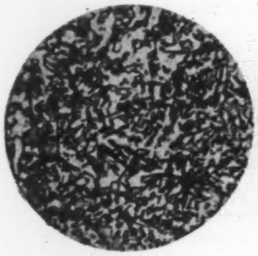
Behavior of steels at low temperatures is very dependent upon microstructure. Here again, on the basis of tensile testing, the tempered martensite steels are superior to the pearlitic steels. Pearlitic or temper-brittle steels break brittlely in the tensile test at low temperatures, whereas tempered martensitic steels of moderate yield do not break brittlely even at very low temperatures. Variation in reduction of area (as a measure of the strain to fracture) is illustrated in Fig. 4 for both pearlitic and tempered martensitic structures in a typical steel. In martensitic steels, the strain to fracture decreases only gradually as testing or service temperature decreases.

Using Hardenability Data: Microstructure of steel is controlled by the hardenability under a given set of cooling conditions, so the designer must know that the steel will have a suitable hardenability in terms of desired microstructure. He can determine this factor by measuring it in terms of the cooling rate, or some indirect expression of the cooling rate, such as ideal diameter, at which the desired microstructure is obtained. In other words, the martensitic, bainitic, or pearlitic hardenability of a steel can be determined by making a Jominy end-quench test. This test is simple to make, and its results are direct and interpretable (up to 4 in. diam bars).

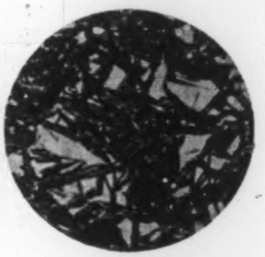
Slack-quenched structures have inferior notch properties compared to tempered martensitic structures at comparable strength levels. For this reason, only deep-hardening steels are normally used for high-strength applications to assure a fully martensitic structure. Recently, however, it has been shown that 4340 transformed to lower bainite can have notch properties superior to those obtained in tempered martensitic structures, Fig. 5. Such bainitic structures, however, will not attain the highest desired strength levels obtainable for tem-

Affects Steel Properties

Bainite



Lower bainite

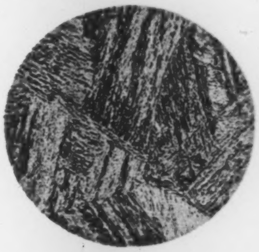


Upper bainite

	Yld Str (psi)	Ten Str (psi)	Elong (% in 1")	Red Area (%)	Trans Temp (F)
Upper	136,300	160,700	15.5	67.0	+50
Lower	115,900	135,600	17.0	68.5	−185

Transformation to bainite occurs over the range from 1000 to 450 F. Bainite microstructures are needle-like (acicular). Again, hardness increases as the transformation temperature decreases and the bainite structure becomes finer. Hence, upper or coarse bainite formed at the higher temperatures can be contrasted with lower or finer bainite formed at the lower temperatures.

Martensite



Untempered martensite

	Yld Str (psi)	Ten Str (psi)	Elong (% in 1")	Red Area (%)	Trans Temp (F)
Tempered, 1100 F	130,700	148,800	18.0	65.0	−225
Tempered, 1200 F	96,200	110,200	22.5	75.0	−200

With even more rapid cooling (quenching), the austenite can be transformed directly to martensite at temperatures below 450 F. Martensite is the hardest and most brittle microstructure until tempered, and percentage formed depends only on the temperature to which the steel is cooled. Its structure is also acicular, but generally finer than that of bainite. On tempering martensite, a relatively high toughness at any strength level is obtained. Because of its high ductility at a given hardness, a martensitic structure is aimed for in heat treating for toughness by quenching and tempering.

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pered martensite. Taking all of the data into consideration, the designer can conclude that bainites are less harmful than pearlitic structures and that even 10 per cent bainite has generally only a very moderate effect on the properties of tempered martensite. Therefore, he can confidently use a 90 per cent rather than a 100 per cent martensitic structure.

Table 1—Jominy Test Hardness versus Section Thickness*

Maximum Thickness (in.)	Position on Jominy Curve Used to Assign Hardness Value (in.)
Up to ½	1/16
½ to 1	2/16
1 to 1½	3/16
1½ to 2	4/16

*4340 steel.

Often a full martensitic structure cannot be attained in quenching because of the large section size involved or because of added cost for the appreciable alloy content required. Furthermore, transformation to martensite in such large sections would set up high stresses that would make this heat treatment impractical. Therefore, the size limitation in obtaining martensite must be recognized, and a composite microstructure accepted. The position on the Jominy hardenability curve used to determine the hardness of the "as-quenched" steel depends on the size of the piece. An example of this very useful measurement for design is shown for 4340 steel in Table 1.

In essence, the Jominy test allows one to select a steel with proper hardenability characteristics to give adequate mechanical properties in the section size conforming to the end use. The practical value of hardenability data to the designer is that it will reveal if slack-quenched structures (which produce lower yield strength on tempering) will occur in heavier sections. These effects of section size are most pronounced in the as-quenched and other very hard conditions. As the tempering temperature is increased, deviations of the properties of slack-quenched material from those of tempered martensite become smaller.

Choosing the Right Alloy: Once the hardenability requirements are established, the next step is to choose the alloy content which will furnish

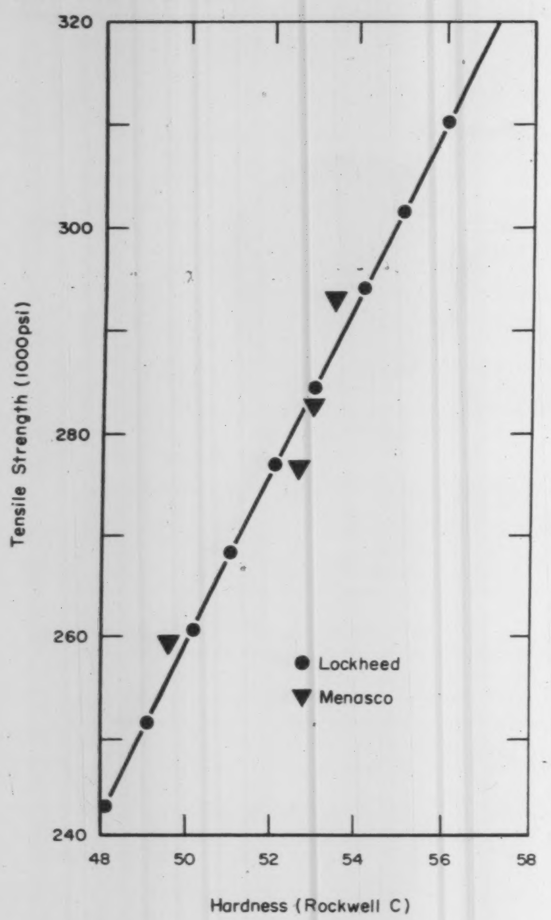


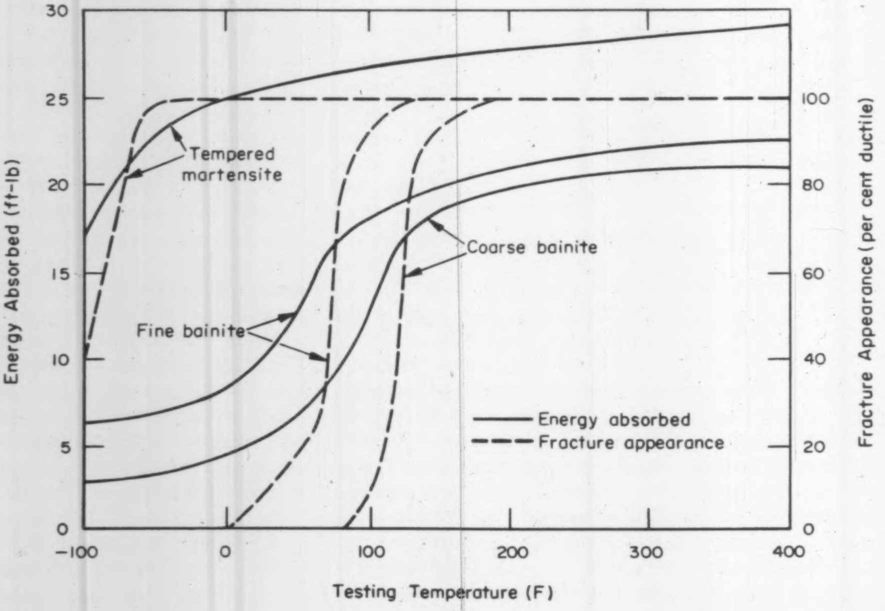
Fig. 2—Relation between tensile strength and hardness for 4340 steel, heat treated to very high strength levels

this hardenability. It is now well established that alloy steels have similar room-temperature properties when quenched and tempered to a particular strength level provided the quench is drastic enough to produce full hardening. Steels of 0.30 to 0.50 per cent carbon content which are heat treated to fully martensitic structures, and subsequently tempered to a particular strength level, have almost identical mechanical properties regardless of the combination of alloying elements used to provide the necessary hardenability.

Knowledge of the effects of alloying elements on bainite or pearlite hardenability is, unfortunately, much more meager than on martensitic hardenability. Here, proper steel selection must be made on an individual basis, without the choice of several steels that provide martensitic hardenability in the smaller section sizes. Bainitic or pearlitic hardenability is the criterion for selection of a steel for use in heavy sections, and the steel should be selected in terms of the cooling rate for transformation to fine bainite (or pearlite). Such structures are generally preferred and are very commonly used in heavy forgings where relatively high strengths are required, and for which the alloy requirement to obtain tempered martensite would be excessive because of size.

The steel composition must transform to banite without prior transformation to pearlite and, if possible, with minimum ferrite precipitation. Steels with a bainitic microstructure are, as a class, both stronger and tougher than pearlitic steels. In both cases, precipitation of ferrite which produces a mixed structure should be avoided. Avoiding ferrite under these circumstances is a most difficult problem. Again, the Jominy test is of considerable value because it reveals not only the depth back of the surface to which pure martensite extends but also the presence of bainite and pearlite beyond this depth.

Fig. 3 — Impact strength, transition temperatures, and fracture appearance for martensite, coarse bainite, and fine bainite. (Cr-Mo-V forging steel, Rockwell C 32, Ref. 2)



Effects of Carbon Content: Carbon content is particularly significant in determining design properties and is a major factor in heat treating to high strength values. In small sections fully quenched to martensite, the hardness of steel is determined by carbon content, and the alloy content is of little significance. However, the principal function of alloying elements is to increase hardenability, and addition of most alloying elements also results in more strength and hardness at a given tempering temperature. Once more, the Jominy test is most useful in evaluating steels, and similarity of Jominy curves proves to be an adequate criterion of ability to substitute, regardless of chemical composition of the metal.

Since weldability, formability, and machinability are important properties favored by low carbon content, an alloy steel should contain the lowest carbon content at which desired strength can be obtained with a suitable heat treatment. Furthermore, for maximum notch toughness and ductility, the carbon content should be no higher than necessary to produce the required strength level. The cooling rate to be used in heat treatment will be established by hardenability of the steel. If the heat treatment includes a tempering treatment, optimum properties can be obtained by tempering at the temperature corresponding to the peak in the impact versus tempering temperature curve.

Avoiding Temper Embrittlement: Tempering at the peak of the impact curve avoids the embrittlement that occurs in most alloy steels when tempered in the 500 to 700 F range. This embrittlement range has been raised by increasing the silicon content or by using hot-work type steels that can be tempered at higher temperatures and still achieve the same strength level. Temper embrittlement is another behavior that occurs in many alloy steels on holding for long times in the tempering range of 850 to 1200 F, or on slow cooling through this range from tempering. Molybdenum and tungsten are known to inhibit this transformation, whereas high chromium, manganese, and phosphorus are likely to increase its occurrence. These temper-embrittlement phenomena must be reconciled with other factors deemed most important.

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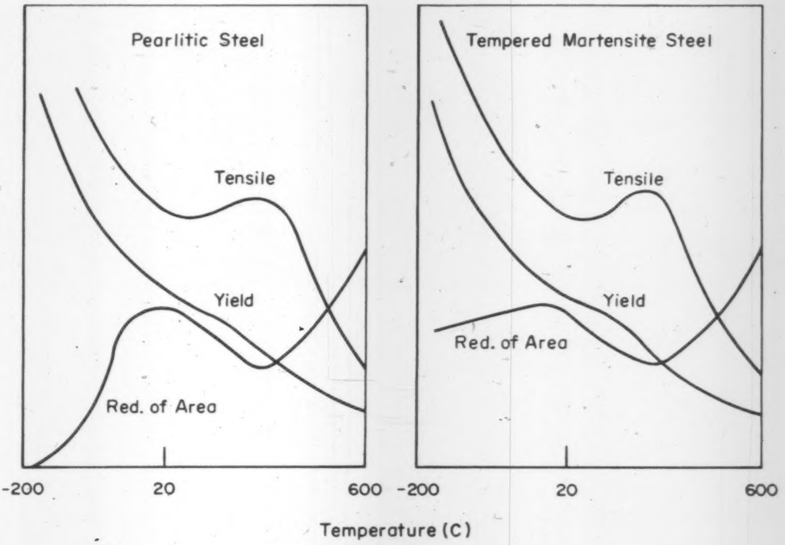


Fig. 4—Effect of temperature on tensile properties of pearlitic and tempered martensite steels (Ref. 3)

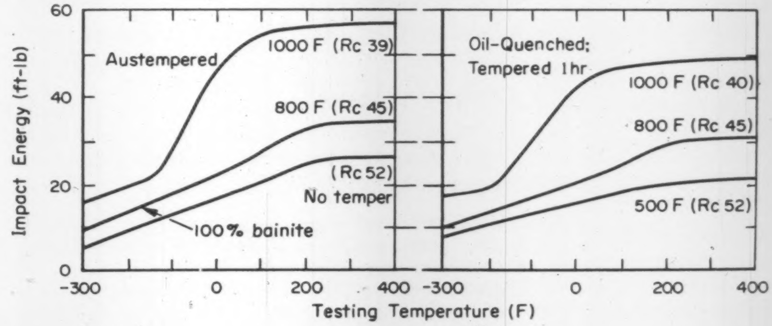
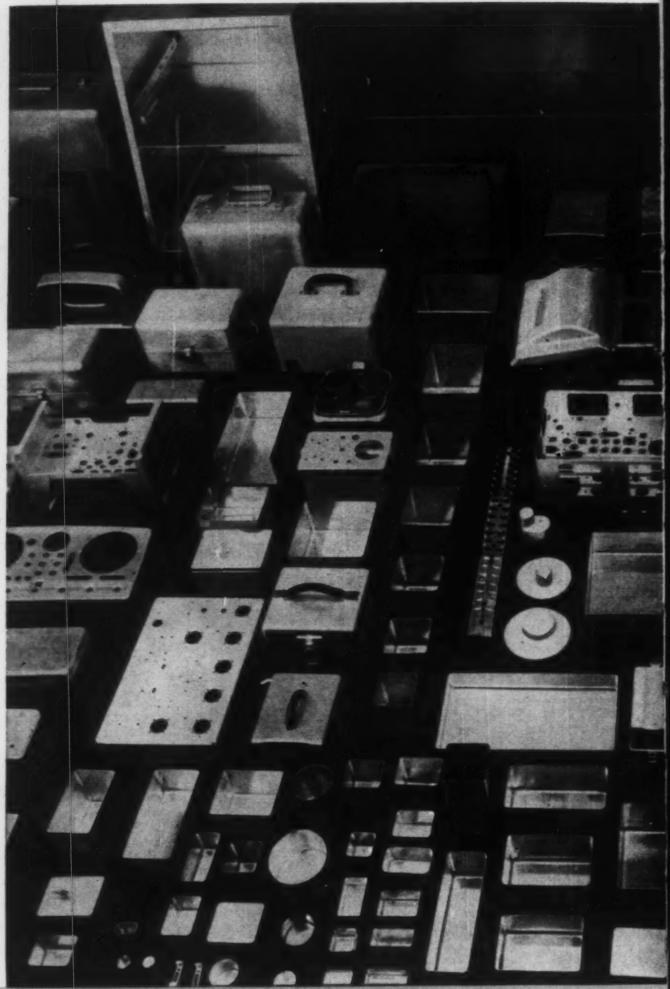


Fig. 5—Transition curves for bainitic microstructures, and quenched and tempered steels (4340, Ref. 4)

ELECTRONIC CHASSIS DESIGN

By FRANK WILLIAM WOOD JR.
Design Engineer
Vitro Laboratories
Silver Spring, Md.

Chassis design problems center around laying out the components and selecting the right chassis shapes, materials, and finishes. Heat-producing parts as well as heat and radiation-sensitive devices complicate the picture. In addition, designing for appearance, maintenance, and lowest possible cost cannot be overlooked. Guideposts for solving these chassis design and selection problems are given in this article.



BEFORE starting actual layout of an electronic chassis, the designer should have the following information:

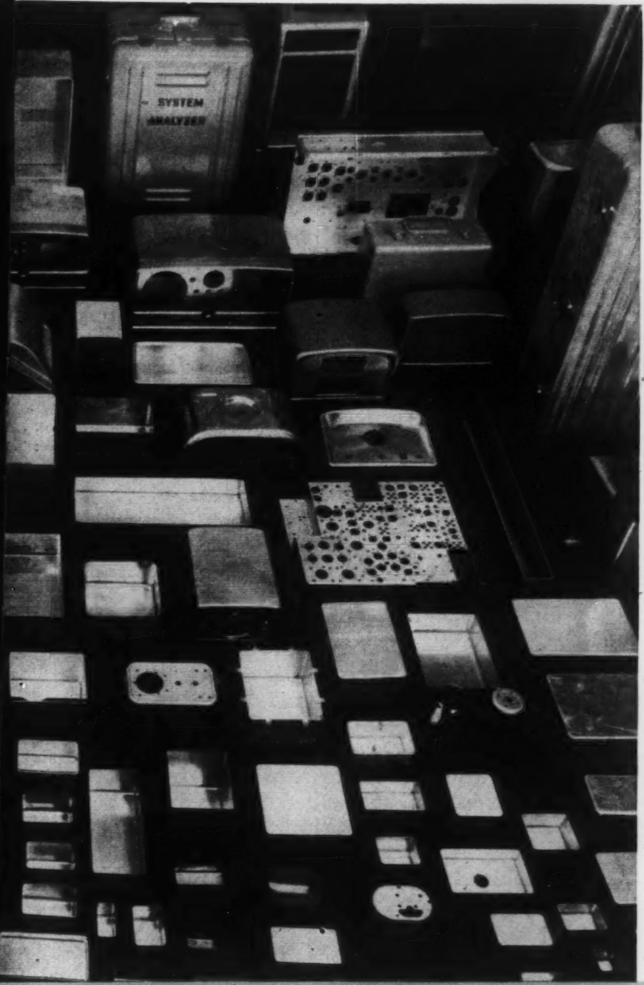
1. Schematic diagram.
2. Detailed parts list of all electrical and electronic components with their values and manufacturer.
3. Outline drawings of all components with dimensions. If not available, actual components can be used for layout purposes.
4. General shape of the chassis.
5. Location and orientation of chassis in equipment.

Also, before the layout is begun, it is sometimes helpful to use paper cutouts of the components which can be moved around within the chassis area outlined on the drawing board. These cutouts can be very helpful in quickly determining the most likely component arrangement and, at the same time, spacing between the components can be obtained.

Component Layout

The arrangement of the individual components on the chassis, such as shown in Fig. 1, depends on many design factors, including:

1. Heat dissipation.
2. Circuit requirements and types of circuits—power supply, receiver, transmitter, etc.
3. Frequency range—low frequency, high frequency, vhf, uhf, etc.



Photos, courtesy Zero Mfg. Co.

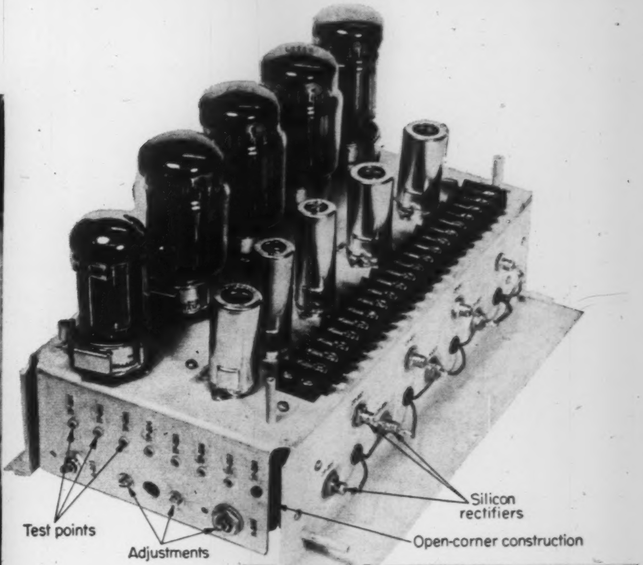
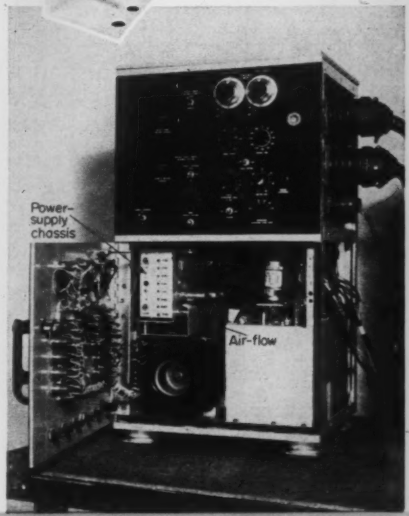


Fig. 1—In-line tube layout is applied in high-wattage power-supply chassis which is mounted on its side in equipment. This chassis dissipates 500 w of power. Chassis serves as heat sink for silicon rectifiers. Open-corner chassis construction minimizes layout and fabrication problems. Test points and adjustment controls are highly accessible



Photos, courtesy Servonics Inc.

4. Maintainability.
5. Interreaction between components.
6. Ease of assembly.

In general, the best chassis design is one that utilizes a symmetrical layout. In short, a maximum number of holes and cutouts should be laid out along a common center line, Fig. 2*a* rather than placing them in a random arrangement, Fig. 2*b*, if at all possible. The symmetrical layout offers several advantages:

1. Saves drafting and checking time and results in fewer errors because there are fewer dimensions.
2. Reduces layout time and errors in fabrication.
3. Adapts more readily to automatic punching machines.
4. Simplifies stencil for part marking.
5. Increases feasibility of using preformed cable or wiring harness.

A typical in-line layout is shown in Fig. 1 for a regulated power-supply chassis.

The tendency in chassis design today is to let miniaturization, which is highly desirable in aircraft and shipboard equipment, overshadow the problems that arise from reduced size, such as inadequate cooling and spacing of components.

Also another common design approach which should be avoided is that of placing a short tube or component between two or more taller components allowing insufficient hand room to remove the smaller component without first removing the taller ones. If possible, all components should be mounted

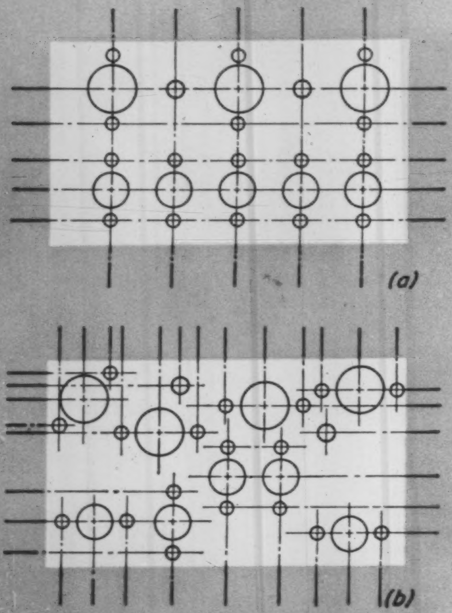
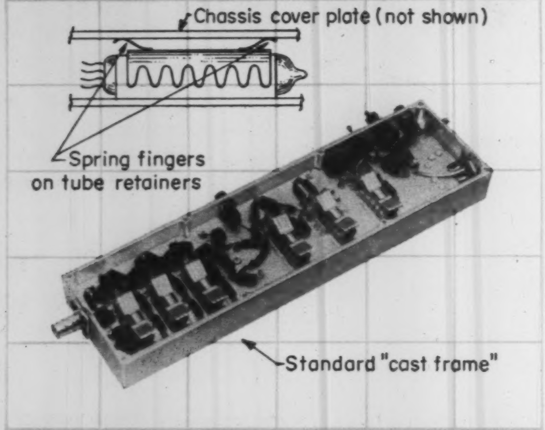


Fig. 2—Electronic chassis layout is simplified by using a minimum of common center lines, *a*, as compared to a random arrangement, *b*

Fig. 3—"Cast-frame" chassis with removable top and bottom cover plates. Spring fingers on tube retainers dissipate heat from tubes to chassis cover plate
Photo, courtesy Lel Inc.


Chassis cover plate (not shown)
Spring fingers on tube retainers
Standard "cast frame"

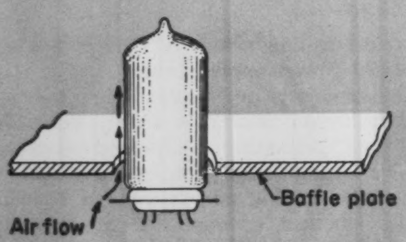


Fig. 4—Chassis baffle plate produces a chimney cooling effect over surface of tube

to allow replacement with minimum handling of other components.

Location of Hot Components

Special attention should be given to the location of high heat-dissipating components, such as, high-current tubes and high-wattage resistors. It is important to protect the component itself and not allow it to go beyond its allowable rating. Also adjacent heat-sensitive components, such as capacitors, transistors, crystal diodes, etc., should be protected.

It is necessary to hold tube envelope temperatures to some predetermined level to obtain the desired tube life and performance. This can be accomplished in several ways.

1. Locate tubes on the chassis for maximum air circulation. For example, moving tubes from a circulation-blocked enclosure to the outer edge of the chassis is often helpful.
2. Use correct tube shields and liners to dissipate heat back through the chassis by conduction, Fig. 3.
3. Use "chimney cooling" technique, Fig. 4.

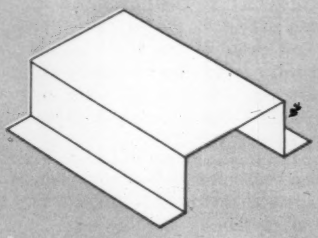
There was quite a heat-dissipation problem with the power-supply chassis assembly in Fig. 1 because of the design compactness required and high wattage involved. Another design challenge in this unit was to hold the silicon rectifiers at the lowest possible temperature for maximum efficiency. The design shown was decided upon after determining that the chassis would be mounted in the final con-

Checklist for Electronic Chassis Design

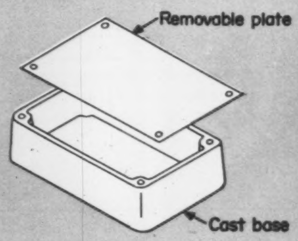
1. **Factors Affecting Type and Style**
   - a. Quantity involved.
   - b. Availability of standard chassis.
   - c. Time schedule.
   - d. Available fabricating facilities.
   - e. Size.
   - f. Strength required.
   - g. Special configuration required.
   - h. Special material required.

2. **Design Suggestions**
   - a. Specify bend radii large enough to prevent breaking material.
   - b. Choose finishes best suited for chassis material used.
   - c. Make sure chassis is stiff enough to properly support transformers and other heavy components.
   - d. Allow sufficient space between corner radii and component mounting screws.
   - e. Use standard hole shapes wherever possible.
   - f. Leave sufficient room for wires and cables.
   - g. Allow maximum tolerances on hole sizes and locations.
   - h. Allow sufficient room for marking component reference designations.
   - i. Locate individual components for easy removal.

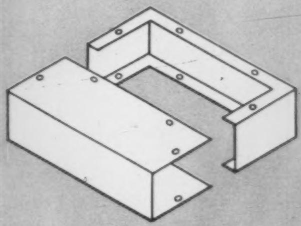
Basic Chassis Shapes and Designs



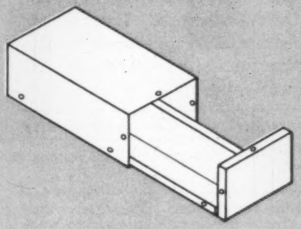
Formed "hat" chassis. Design is inexpensive and requires only a brake to form, but is not shielded.



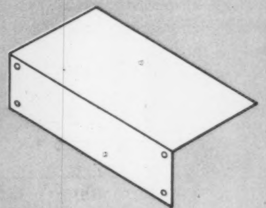
Cast-base chassis. Constructed with a removable cover plate, the design offers a strong shielded enclosure which is easy to maintain. Cost is high in small quantities, and weight may be prohibitive in some cases.



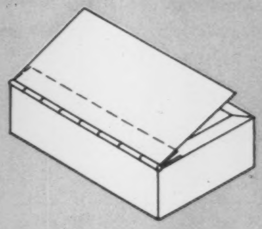
Mating-construction chassis. Commercially available in a number of styles, this design provides excellent accessibility. However, all feed-through components must be placed on standoffs or brackets.



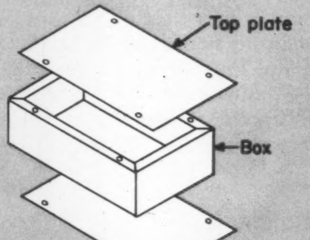
Two-piece sliding chassis. Commercially available in a number of sizes, this design is also highly accessible. Here, too, all feed-through components must be placed on standoffs or brackets.



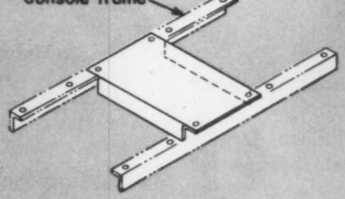
L-chassis. Design advantages are simplicity and cost savings, although little protection is offered to electronic components.



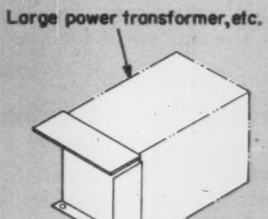
Box chassis with hinged lid. Quick accessibility to components inside is major design advantage. Enclosure provides good shielding. The hinge adds to cost.



Box chassis with removable top and bottom. Design provides excellent accessibility from top or bottom and can be purchased from commercial stock in various sizes.



Flat chassis with stiffener flanges. This construction is lightweight, low in cost, and allows use of modular design in final packaging. Although chassis is easy to form, it requires the use of a shear, nibbler, and brake.



Combination mounting bracket and chassis. The flanged dual-purpose design can be employed for mounting large components.

Table 1—Typical Electronic Chassis Materials and Finishes

Chassis Material	Finish	Process Description	Characteristics
Aluminum	Alodine	Chemical conversion coating applied by immersion, spray, or brush.	Good corrosion resistance. Offers good paint adherence. Low electrical resistance. Can be used on aluminum assemblies containing dissimilar metal inserts. Scratch in coating can be easily repaired by brush method. Meets military specification MIL-C-5541.
Aluminum	Anodize, chromic acid	Electrolytic oxide coating.	Good corrosion resistance. Offers good paint adherence. Average thickness is 0.00005 in. High electrical resistance. Coating must be removed in areas where good electrical contact is desired. Meets military specification MIL-A-8625A, Type 1.
Aluminum	Anodize, sulfuric acid	Electrolytic oxide coating.	Good corrosion resistance. Offers good paint adherence. Cannot be used on assemblies. Thickness is 0.0001 to 0.001 in. High electrical resistance coating must be removed in areas where good electrical contact is desired. Meets military specification MIL-A-8625A, Type 2.
Aluminum	Iridite	Chemical conversion coating applied by immersion, spray or brush. Immersion time 30 sec to 5 min depending on thickness and color desired.	Corrosion resistance increases with immersion time. Good paint adherence. Low electric resistance. Meets military specification MIL-C-5541. Coating thickness is 0.00002 in. No special equipment required.
Cadmium-plated steel	Iridite	Immersion time 10 to 20 sec	Good corrosion resistance. Good solderability. Tarnish resistance.
Zinc-plated steel	Iridite	Immersion time 10 to 20 sec	Good corrosion resistance. Tarnish resistance.
Aluminum	Wrinkle enamel	Spray or brush. Air dry or bake.	Covers surface defects. Mar resistant.

sole with the tubes in a horizontal plane directly in line with air flow from a blower. The silicon rectifiers were mounted on the lower flange to keep them below the heat from the tubes. Obviously, an electronic chassis must be designed with the location in the equipment known.

▶ Chassis Materials and Finishes

Selection of chassis materials and finishes largely depends on the application. Typical finishes for materials used in electronic chassis are given in Table 1.

Three large application areas for electronic chassis are commercial television and radio, commercial test equipment, and military equipment.

Television and radio equipment designers must design a chassis that is quite economical and is suitable for mass production. This group is not too interested in appearance because in general the public only sees the covering cabinet.

Test-instrument designers also must definitely have economy in mind. However, in this group the equipment will be under the critical eyes of engineers using the equipment. These designers must arrive at a definite stopping point in cost savings to prevent producing a cheap looking instrument.

Military equipment is in a field all its own. Here there have been definite standards set up for both the materials and the finishes which must be followed in military-equipment design. A tabulation of military specifications applicable to electronic chassis design are presented in Table 2.

▶ Design for Maintenance

No electronic equipment has yet been designed that does not require maintenance at one time or another. Through careful chassis packaging, equipment can be designed for easy maintenance, Fig. 5. Here the entire chassis assembly is fabricated as a plug-in drawer with all leads terminating in a connector at the rear of the chassis. Should trouble develop in a unit of this design, the entire drawer-chassis is removed from the console and a "jumper cable" is connected from the console to the drawer.

Table 2—Military Specifications Applicable To Electronic Chassis Design and Assembly

Item	Subject	Military Spec.
Chassis	Material selection and specification	MIL-E-19100 3.5.11.1
Chassis	Finish	MIL-E-19100 3.5.13 MIL-E-19100 3.6.3
Chassis	Marking	MIL-E-19100 3.13.4 through 3.13.4.4
Connectors Terminal boards Tube sockets	Selection and mounting	MIL-E-19100 3.3.14.3
Resistors and capacitors	Mounting of parts with pigtail leads	MIL-E-19100 3.3.50 MIL-E-19100 3.3.50.1 MIL-E-19100 3.3.50.2
Clamps and retainers	Securing of plug-in components	MIL-E-19100 3.3.46 MIL-E-19100 3.3.13
General design	Location of hot components	MIL-E-16400 3.11.15 MIL-E-16400 3.3.5
Chassis wiring	Color coding	MIL-E-19100 3.3.11.2.1 MIL-E-19100 3.9.11.1 MIL-STD 122
Chassis wiring	Insulation through holes	MIL-E-19100 3.9.8.3
Test points	Selection	MIL-E-19100 3.3.14.1.3 MIL-STD 242
Handles	Removing chassis and protecting components	MIL-E-19100 3.11.9.2 MIL-E-19100 3.11.9.3

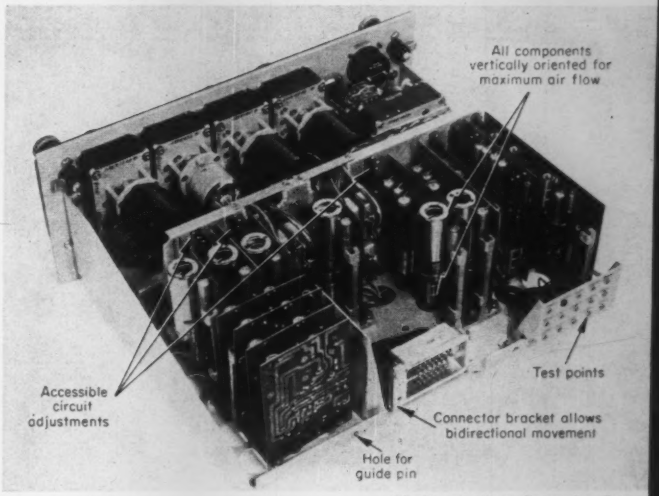
This allows complete observation of all components under actual operating conditions.

▶ Shielding and Isolation

The successful design of a chassis assembly for a receiver, transmitter, high-gain amplifier or other critical electronic equipment requires a basic understanding of circuit functions and the application of adequate shielding. This is particularly true in miniaturized equipment where adjacent circuit components are intermixed with each other without regard to circuit functions.

Here are some basic rules to minimize intercoupling between circuits:

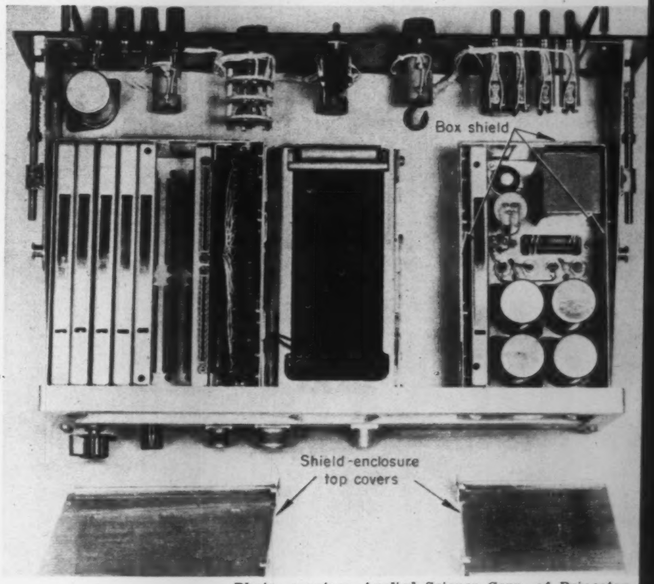
1. Use maximum separation between input and output circuits.
2. Separate signal and power leads as much as possible.
3. Shield signal leads.
4. Reduce lead length to a minimum.


All components vertically oriented for maximum air flow
Test points
Connector bracket allows bidirectional movement
Hole for guide pin
Accessible circuit adjustments

Photo, courtesy Servonics Inc.

Fig. 5—Highly accessible drawer-chassis design. Bracket on rear electrical connector allows bidirectional movement to compensate for any misalignment. Circuit adjustments are easy to make, and test points are in one location. Practically all circuit components are vertically oriented to take maximum advantage of air flow

Fig. 6—Chassis enclosures designed for complete shielding of individual stages in equipment



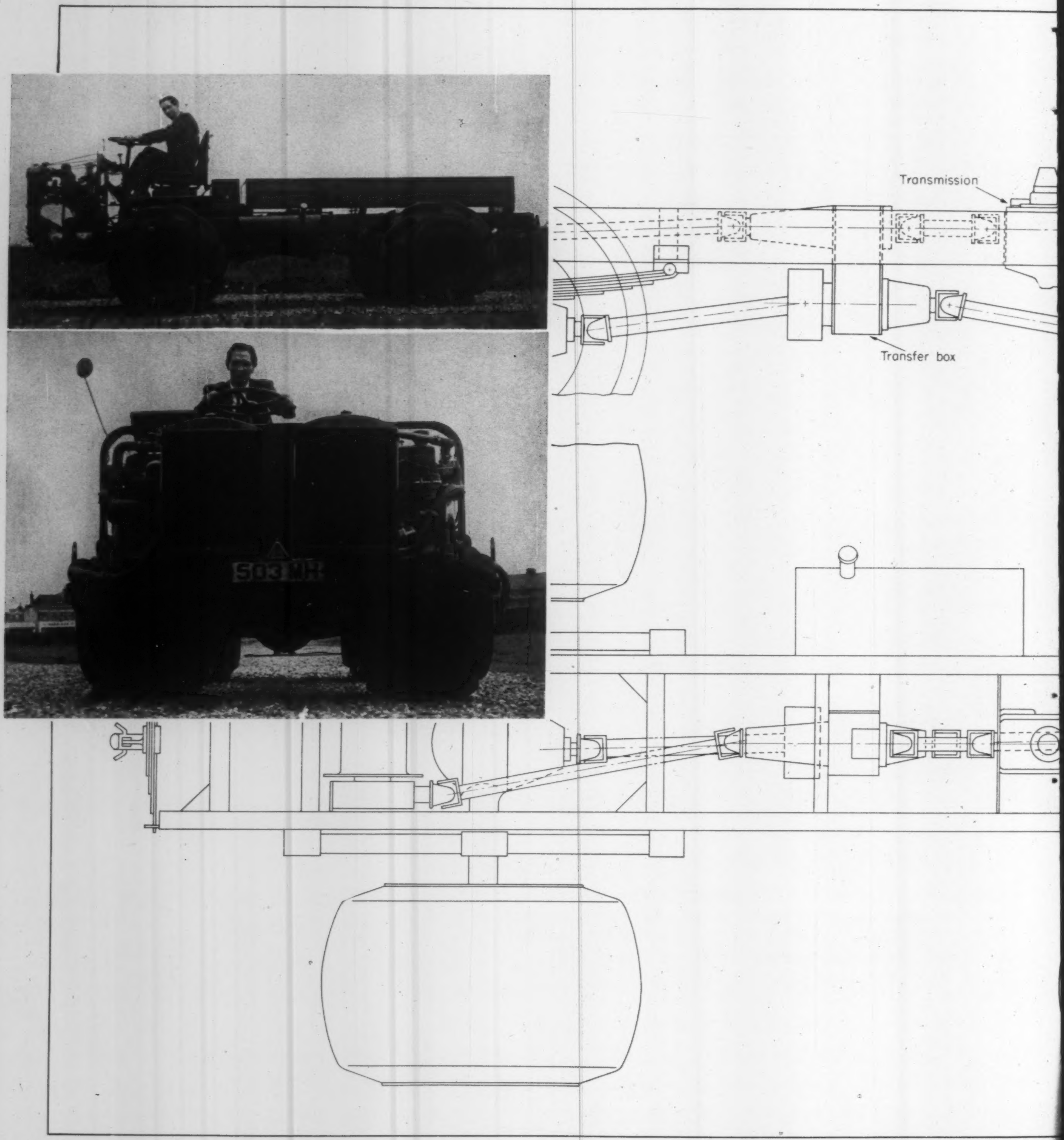
Photo, courtesy Applied Science Corp. of Princeton

To minimize intercoupling of electron tubes, use slip-on shields that are grounded to the chassis. Transformer intercoupling can be minimized by positioning power-transformer cores at right angles to input or interstage transformers and by avoiding open-frame transformers.

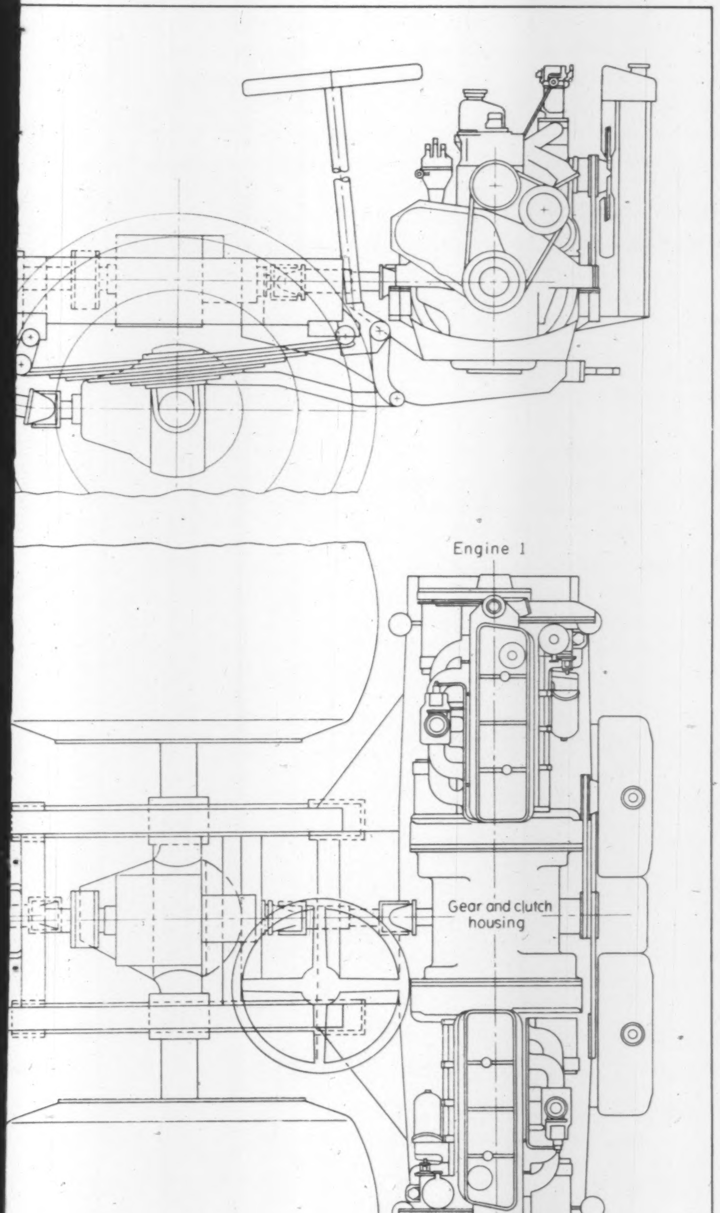
In transmitters and receivers, it sometimes becomes necessary to provide shielding between components of different stages. This can be done in several ways:

1. Full-height metal chassis dividers.
2. Smaller divider shields across centers of tube sockets.
3. Individual component shields.
4. Cast chassis design incorporating shield baffles.
5. Slip-on tube shields.
6. Complete stage enclosures, Fig. 6.

Two Engines Mounted Transversely

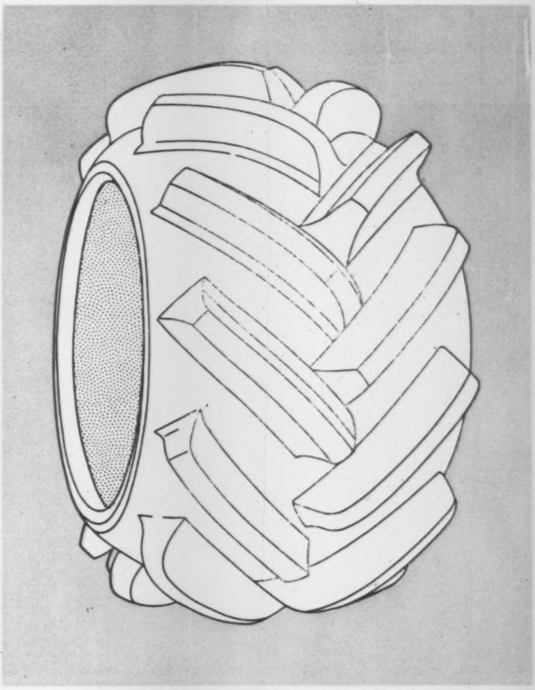

Transmission
Transfer box

Drive Common Output Shaft



VEHICLE RELIABILITY is automatically doubled by using two independently controlled engines as reported by Nicholas Straussler & Co. Ltd., London, England. Each engine can be operated separately since the electrical system for each is completely duplicated. Placed in a transverse position in front of the front tires, the two engines are connected together to form a single rigid unit by the common bevel gear and clutch housing. Both axles are driven and the front axle can be uncoupled at will.

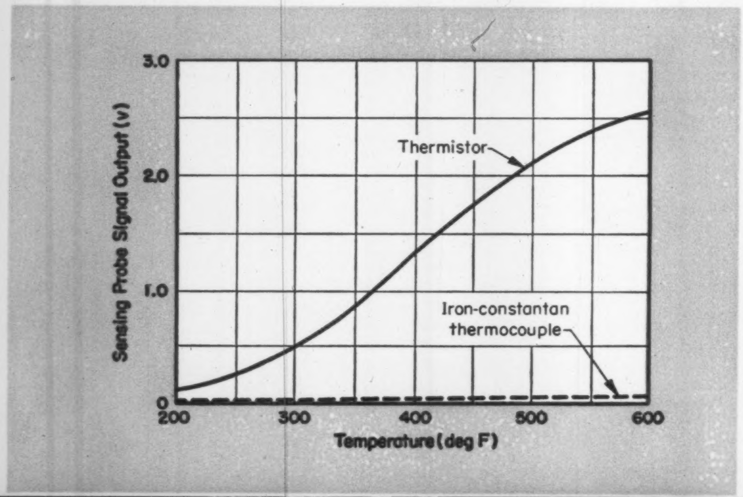
ARC CROSS-SECTION TIRE design on the four-wheel drive lorry produces only a small angular deflection in the tire carcass. The low air pressure (2/3 psi) permits large inward deformation of the tire. Obstructions such as rocks and stones 10 in. high can be run over without tire being lifted off the ground.

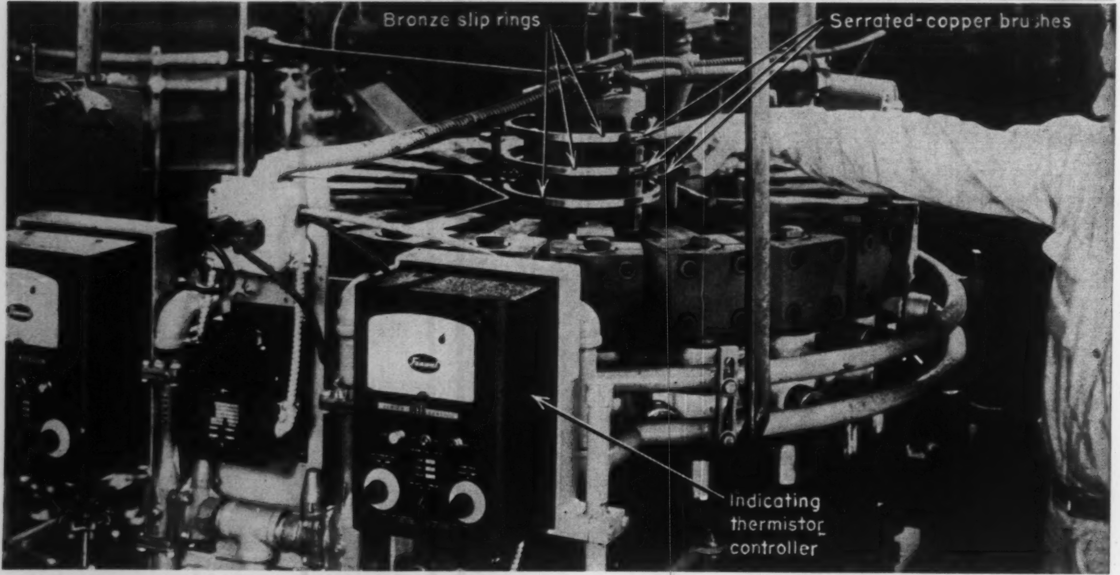


Large Resistance Changes in Thermistors Make Brush-and-Ring "Connectors" Practical

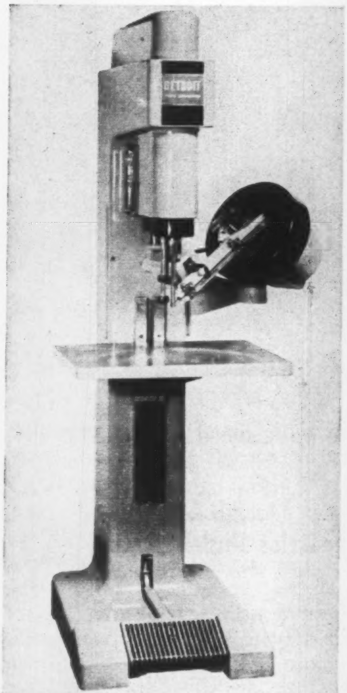
REMOTE TEMPERATURE SENSING problems in rotary molding presses at Sylvania's Warren, Pa., plastics plant have been licked by using thermistor controllers and special-design slip-ring "connectors." As reported by the press manufacturer, Cropp Engineering Div., El-Tronics Inc., temperature signals can be accurately transmitted through slip rings because of the exceptionally high output of thermistor circuits. With iron-constantan thermocouples, this has not been practical because of their low output.

Plastic parts are molded and cured in this machine by heat supplied to the cast-iron platens—a total of 20 pairs—as they rotate past two groups of 2-in. radiant-heat gas burners arranged on two fixed circular manifolds surrounding the ring of platens. Each group of burners is controlled by an indicating thermistor controller manufactured by Fenwal Inc. Separate control of each group of burners permits the temperature of the upper and lower platens to be adjusted independently to compensate for differential heat losses and various part configurations. The thermistor sensing probe for each controller is inserted in a special cored platen in the upper and lower ring of platens. The leads from each thermistor probe are wired to a pair of spring-loaded, serrated-copper brushes, mounted on insulated supports fastened to the rotating part of the press. The temperature sensing signal is picked off each set of brushes as they wipe against ½-in. wide bronze collector rings fixed on the stationary center post of the press. The probe signals from the collector rings are brought out through conduits to the two thermistor controllers which are mounted beside the press.





Clutch Locks Out Automatically At Predetermined Torque Value

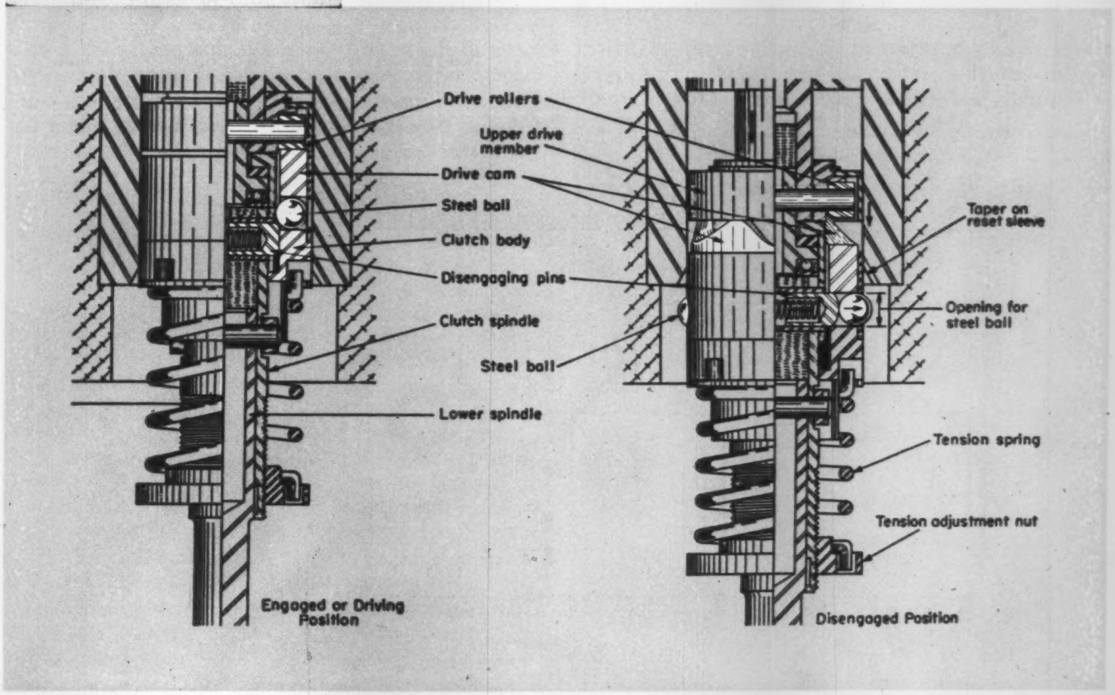


CAM-AND-ROLLER CLUTCH permits a magazine-fed power screwdriver to hold a contact torque. Built by the Detroit Power Screwdriver Co., subsidiary of Link-Belt Co., the clutch is unaffected by temperature changes or excessive oil or grease. Clutch torque can be adjusted over a range of 15 to 120 lb-in. with a tolerance of plus or minus 2 lb-in. at the low end and 6 lb-in. at the high end.

ROTARY DRIVE POWER, which is transmitted through drive rollers engaged with a drive cam, turns the clutch body along with the clutch spindle and the lower spindle. When a given screw is driven to the desired predetermined torque, the drive rollers force the clutch body down against thrust of tension spring until openings in the clutch body come in line with the disengaging pins. Forced outward by internal springs, the disengaging pins lock the clutch body down, completely separating the clutch body and spindle from the upper drive spindle. When the clutch is in the disengaged position, the drive rollers pass over the high points of the cam face.

After a screw is installed and the mechanism returns to the "up" position, the disengaging pins are forced out of the openings in the clutch body when the steel balls are forced in by the taper on the reset sleeve. This action permits the clutch body to return to the driving position with the drive rollers again engaged with drive cam face.

Clutch drive torque is controlled by the tension spring which is adjusted by a nut.


Drive rollers
Upper drive member
Drive cam
Steel ball
Clutch body
Disengaging pins
Clutch spindle
Steel ball
Lower spindle
Taper on reset sleeve
Opening for steel ball
Tension spring
Tension adjustment nut
Engaged or Driving Position
Disengaged Position

THERMAL STRESSES IN DESIGN

Part 5—Interpretation of Fatigue Data for Ductile

By S. S. MANSON
Chief, Materials and Structures Div.
Lewis Flight Propulsion Laboratory, NACA
Cleveland, Ohio

MOST of the investigations and literature on the subject of thermal-stress fatigue in ductile materials have been limited to evaluations of a few materials under a given set of conditions. From an engineering viewpoint, this type of comparison is important because of its immediate application to the problem at hand. In addition, discussion in the previous two articles[3, 4] in this series has been confined to the direct effect that thermal stress has on the fatigue failure of ductile materials.

However, to extend application of this information it should be reduced to fundamentals. Therefore, an effort is made in this article to interpret these results in general terms, and effects of thermal-stress fatigue on those material properties that are involved in failure are considered.

▶ Mechanical Properties Under Cycling

Importance of thermal-stress cycling on life of a part is limited not only to number of cycles that can be withstood before failure occurs due to the thermal stress, *per se*, but also to its effect on other mechanical properties which govern the life of the material. In a turbine bucket, thermal shock occurs during starts, stops, and accelerations to rated speed. Thermal stresses may conceivably weaken the material so that its strength in stress-rupture under the

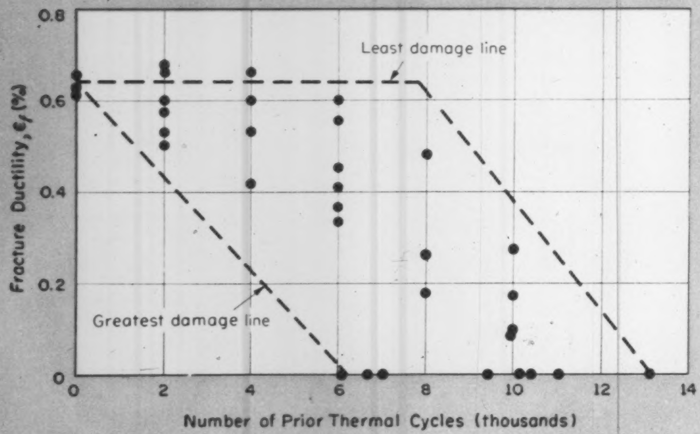


Fig. 31 — Room-temperature tensile ductility as affected by prior thermal cycling. Severity of damage is shown for type 347 stainless steel

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[3] References are tabulated at end of article.

Materials

- **Mechanical Properties Under Cycling**
- **Prior Straining**
- **Distinction Between Thermal and Mechanical Fatigue**
- **Design Applications**

conditions of high temperature and centrifugal stress may be appreciably reduced.

Coffin[5] found that thermal-stress cycling caused cracks to appear early in the life of the specimen, but that progress of the crack was quite slow in subsequent cycles. By determining room-temperature stress-strain curves for specimens subjected to various numbers of thermal cycles, he found that for type 347 stainless steel:

1. The larger the number of prior thermal-stress cycles, the more elevated the stress-strain curve; that is, the specimen became more strain hardened.
2. Cracks developed by thermal-stress fatigue acted as nuclei for subsequent crack propagation in tension. However, the bulk of the material was not significantly deteriorated by the prior thermal-stress fatigue except when large numbers of cycles were involved.
3. Fracture ductility could be appreciably decreased by the cracks initiated by fatigue. However, the scatter was quite wide, and the effect was a statistical one, where some specimens showed little loss in fracture ductility even after prolonged cycling. When the upper and lower limits of the scatter band were considered, lines of least and greatest ductility damage could be plotted, Fig. 31. However, judgment must be exercised by the designer in using these data as a guide in practical applications.

Hardening: The amount that thermal-stress cycling hardens a material depends on the initial hardness condition of the material prior to cycling. It appears that, if the material is of high hardness as a result of prior working, alternating strain may soften the material rather than cause further hardening. This phenomenon was first discussed by Polakowski and Palchoudhuri[6] in connection with conventional fatigue tests.

More recently, Wood and Segall[7] investigated the problem in a strain-cycling test, where the

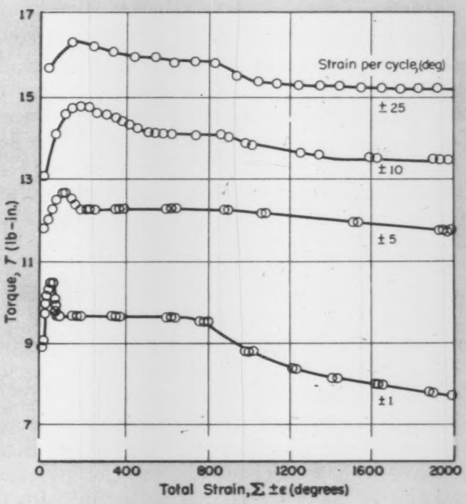

Fig. 32—Alternating stress-strain curves. Similarly worked copper specimens were subjected to alternating plastic strains of different amplitudes

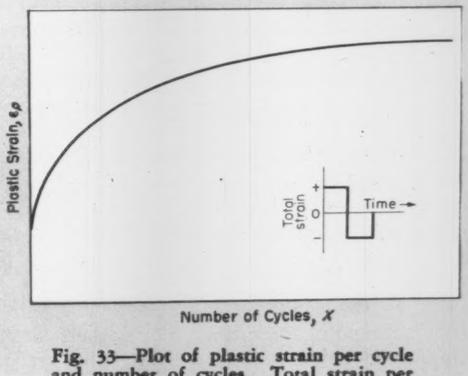

Fig. 33—Plot of plastic strain per cycle and number of cycles. Total strain per cycle was maintained constant

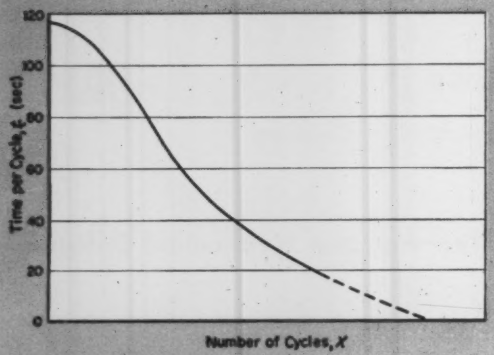

Fig. 34—Time per cycle and number of cycles, with approximately constant plastic strain

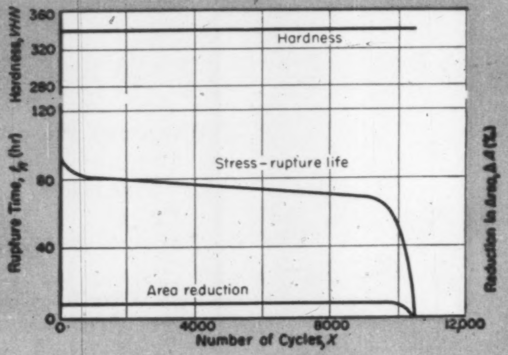

Fig. 35—Thermal-stress, effect on hardness and stress-rupture life of Inconel 550. Cycle temperature was maintained between 200 and 1350 F. Rupture stress was 56,500 psi tensile at 1350 F

specimen was subjected to cycles of positive and negative plastic strains of equal magnitudes. The tests were conducted at such a speed that heat generation was eliminated as a softening influence.

Copper test specimens were initially hardened by a 70 per cent reduction in diameter and then subjected to alternating plastic strains of plus or minus 1, 5, 10, and 25 degrees. Changes in hardness were indicated by the torque necessary to cause the plastic flow, after the various numbers of reversed strain cycles. This torque is plotted, Fig. 32, against the total prior plastic strain, which is the sum of all the strains without regard to sign. In all cases there was an initial increase in hardness which was followed by a softening effect.

Although these tests were conducted at constant temperature, the implications regarding thermal stress are evident. Depending on the initial condition of the material, alternate straining by thermal stress may soften the material and reduce its load carrying ability in tension or creep.

More direct evidence of the softening phenomenon due to alternating strain was presented by Kennedy,[8] in tests performed on Inconel at elevated temperatures. Again, these tests were at constant temperature, but implications can be drawn regarding thermal-stress fatigue. Fig. 33 shows that when the total strain, elastic plus plastic, was maintained constant in successive cycling, the plastic portion of the strain progressively increased, indicating a softening of the material.

When the load was maintained constant, Fig. 34, the time required to produce a given plastic strain progressively decreased with an increase in prior strain cycles. Both of these figures indicate that Inconel, in the condition tested, softened as a result of alternating straining. Thus, thermal-strain cycling could cause it to lose strength or creep resistance.

Stress-Rupture Life: The effect of prior thermal-stress cycling on subsequent stress-rupture life for S-816 and Inconel 550 was determined by Clauss and Freeman.[9] In each case, the thermal-stress cycling was between 1350 and 200 F. Specimens were removed from the rig after a number of predetermined cycles and evaluated in stress-rupture under the same conditions of stress and temperature. For S-816, the evaluation conditions were 40,000 psi and 1350 F, and for Inconel 550, 56,500 psi at 1350 F. For Inconel 550 a progressive decrease in stress-rupture life occurred with an increase in the number of thermal-stress cycles, Fig. 35. The decrease was more severe when the cycling took place at a higher maximum temperature, as will be discussed later. Also, the hardness, measured after removal from the rig, did not change. The reduction in area at fracture in the stress-rupture test did not drop appreciably until the specimen was near its fracture point in thermal-stress fatigue.

On the other hand, alloy S-816 showed an entirely different behavior, Fig. 36. When the specimen was removed after a small number of cycles, there was actually an increase in the stress-rupture life. The thermal-stress cycles had increased the hardness, as shown in the upper curve, and had strengthened the material in subsequent stress-rupture testing. Only a small loss in ductility occurred in the stress-rupture test. After larger numbers of cycles, the beneficial effect on stress-rupture life was reduced, but it was not until the specimen was near the fracture point in the thermal-stress test that the life itself declined. Loss of ductility in this case was progressive with number of cycles.

The importance of maximum cycle temperature on the reduction of stress-rupture life was indicated in a series of tests[9] conducted on Inconel 550. The minimum cycle temperature was maintained at 200 F while the maximum cycle temperature was varied, Fig. 37. Specimens were removed from the apparatus after they had completed approximately half the number of cycles required to rupture them in ther-

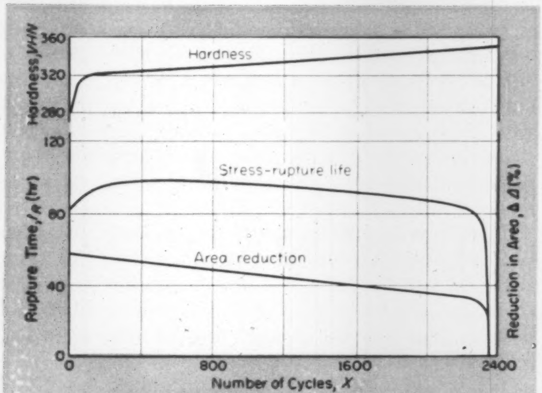

Fig. 36—Thermal-stress effect on hardness and stress-rupture life of alloy S-816. Cycle temperature was maintained between 200 and 1350 F. Rupture stress was 40,000 psi tensile at 1350 F

mal-stress fatigue. They were then tested in stress-rupture at 56,500 psi and 1350 F. Small increases in maximum cycle temperatures, Fig. 37, produced drastic reductions in life.

Part of this decrease was due to associated increases in temperature range, which increased plastic strain both by constraint of greater thermal expansion and by greater localization of strain, and partly because of metallurgical effects associated with the higher temperatures. When the cycling was between 1550 and 200 F, 98 per cent of the stress-rupture life was lost after the specimen had undergone only one-half the number of cycles required to fail it in thermal-stress fatigue alone.

Prior Straining

Subjecting a material to plastic flow prior to exposure to conditions of thermal stress can have important effects on its behavior in thermal fatigue. This topic can be examined from both experimental and analytical viewpoints.

Experimental Determination: Coffin has investigated the effect of prior cold work.[5] Contrary to the situation existing when the material is evaluated in conventional mechanical fatigue, in which prior cold work almost always increases the number of cycles to failure, the thermal-stress fatigue life can actually be decreased in thermal fatigue, Fig. 38, particularly when the strains per cycle are large.

The explanation for this behavior lies in the fact that in a conventional fatigue test, stress is the independent variable, whereas in the thermal-stress fatigue test, strain is the independent variable. Cold work increases the yield point, so that for a given applied stress the plastic strain per cycle decreases. Thereby the number of cycles to failure is increased as compared to the cycles to failure for an annealed material in a mechanical fatigue test.

On the other hand, if the strain is fixed, as in the thermal-stress fatigue test, there is no benefit derived from the cold work, and the reduced ductility caused by the cold work can reduce life.

The effect of prior exposure to stress-rupture conditions on the subsequent behavior in thermal-stress fatigue of S-816 and Inconel 550 has been investigated by Clauss and Freeman.[9] For S-816, Fig. 39 shows that prior application of steady-stress caused progressive decreases in thermal-stress fatigue life. The decreases were almost linearly related to the time of exposure to the steady-stress. However, for Inconel 550, Fig. 40, no deleterious effect of prior stress-rupture conditions was observed on thermal-stress fatigue resistance until the time under steady load approached the rupture time. There was, in fact, a small possible benefit in exposure to stress-rupture on the subsequent thermal-fatigue life, although the data scatter was too great to indicate a conclusive trend.

Analytical Prediction: Thermal-stress fatigue eval-

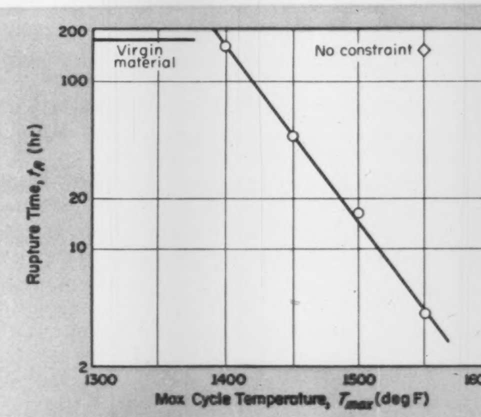

Fig. 37—Effect of maximum cycle temperature on subsequent rupture life of Inconel 550. Minimum cycle temperature was 200 F, and rupture stress was 56,500 psi tensile at 1350 F

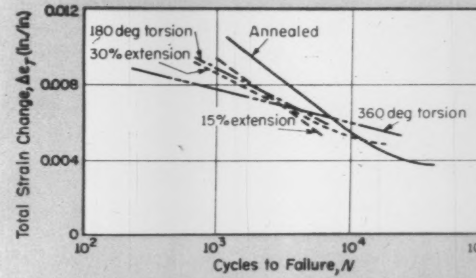

Fig. 38—Thermal-stress resistance of type 347 stainless steel with prior cold work. $\Delta\epsilon_T=\Delta(\epsilon_{elastic}+\epsilon_{inelastic})=\alpha(\Delta T)$

uation involves considerable laboratory testing. Therefore, it is desirable to develop analytical methods for predicting the effect of prior stress and temperature exposure. Equation 11, Part 3 (that is $N = K/\varepsilon_r^n$), is used in this objective.

As a first approximation, it is assumed that loss, or gain, in thermal-stress fatigue is caused by changes in ductility resulting from prior exposure. Thus, it is necessary to measure only the remaining tensile ductility and apply Equation 11 to obtain the effect on the number of cycles to failure.

If Equation 11 is valid for the tensile test, then

$$D^n N_O = K \qquad (12)$$

where D = ductility of the material in the tensile test and N_O = equivalent number of cycles to failure for the tensile test.

When two specimens of a material are exposed to prior steady stress and temperature for different time periods, two conditions of tensile ductility D_1 and D_2 result. Evaluation of the specimens in thermal-stress fatigue, under the same test conditions, indicates that the number of cycles to failure, N_1 and N_2, are related by

$$\frac{N_1}{N_2} = \left(\frac{D_2}{D_1} \right)^n \qquad (13)$$

Thus, if ductility D_1 and number of cycles to failure N_1 are known, the number of cycles to failure, N_2, can be determined by measuring the tensile ductility, D_2.

The temperature at which the ductilities are determined requires some investigation. For the present, however, it is assumed that the maximum temperature of the thermal-stress test is the most pertinent value.

As a crude check on the foregoing hypothesis, predictions of the results shown in Fig. 39 and 40 were attempted. Tensile ductilities were determined for S-816 and Inconel 550 after various amounts of prior stress exposure at 1350 F. Results of these tests are shown in Fig. 41. The ductility of S-816 fell off much more rapidly than that of Inconel 550 after short exposure to stress. Application of Equation 13 to the data, Fig. 41, resulted in the predictions shown by dotted curves in Fig. 39 and 40. Assumed values of $n = 2$ and $n = 3$ were used in these calculations.

These predictions agree almost as well with the experimental data as the solid lines which Clauss and Freeman judged as the most reasonable smooth-curve fit. Although results of this test validate the use of Equation 13, general use of this approach must await more experimental verification.

▶ Distinction between Thermal and Mechanical Fatigue

In many respects thermal-stress fatigue resembles mechanical fatigue at constant elevated temperature. In fact, the theories that have been advanced on the mechanism of thermal-stress fatigue distinguish it little from mechanical fatigue. Coffin[5] has emphasized the role of dislocations which move back and forth between grain boundaries and which, in some undescribed way, cause cracks along the planes undergoing the dislocation motion.

Clauss and Freeman[9] thought of thermal fatigue as consisting of two stages: 1. A hardening of the material due to strain or microstructural precipitation. 2. A breakdown of the atomic bonds when the material has been greatly hardened. Both theories would, if correct, apply equally well to mechanical fatigue and to thermal fatigue.

Between the two types of fatigue, however, there are important distinctions which should be em-

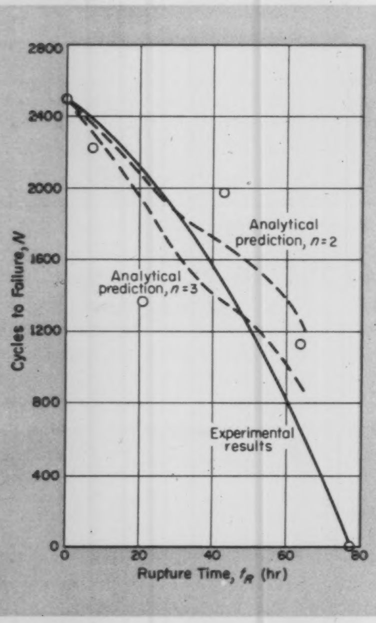

Fig. 39—Left—Effect of stress-rupture conditions on thermal-stress fatigue life of S-816. Cycle temperature was between 200 and 1350 F. Rupture stress was 40,000 psi tensile at 1350 F

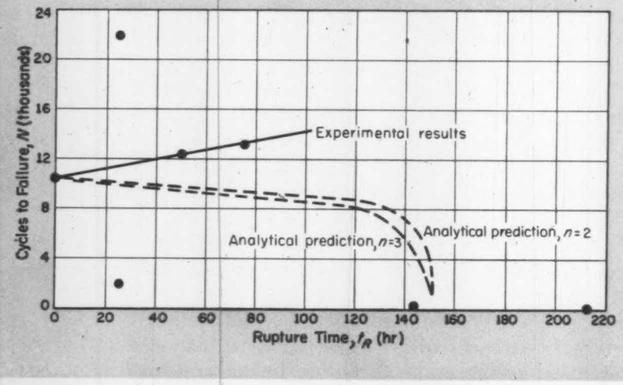

Fig. 40—Effect of stress-rupture conditions on the thermal-stress fatigue life of Inconel 550. Cycle temperature was kept between 200 and 1350 F. Rupture stress was 56,500 psi tensile at 1350 F

phasized if the results of one type of test are to be interpreted in terms of the other.

1. *In thermal-stress fatigue, the plastic strain tends to become concentrated in the hottest regions of the body.* In addition to the strain that would normally be induced in the hot section due to constraint of expansion, this section may be called upon to absorb strain that might otherwise be induced in other regions of the body if the yield point were not reduced by the temperature. Thus the weak link is required to take the maximum burden.

2. *In mechanical fatigue at a constant elevated temperature, the same regions are alternately subjected to plastic flow in tension and compression.* The compressive-plastic flow has a beneficial effect[10] in enabling the material to withstand the tensile-plastic flow.

On the other hand, in a constrained specimen under a temperature gradient, the major compressive-plastic flow occurs in the hot part due to its lower yield point. This plastic flow tends to upset the hot region, increasing the cross-sectional area. Upon cooling, the stress in the upset region is slightly lower than in an adjacent region not upset in compression, because of the higher cross-sectional area. Since the yield point is restored at the lower temperature, there is less tendency to cause plastic flow in tension in the upset region than in the more highly stressed adjacent region. Tensile-plastic flow, therefore, becomes concentrated in the adjacent region, reducing its cross-sectional area.

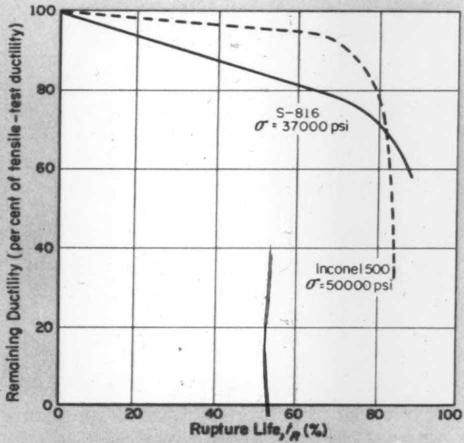

Fig. 41—Effect of stress-rupture conditions on remaining tensile ductility of S-816 and Inconel 550 at 1350 F

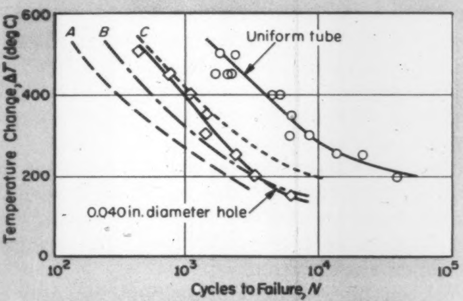

Fig. 42—Fatigue life of thermally cycled type 347 stainless steel with stress concentration. Cycle frequency of 4 cycles per min was induced at a mean temperature of 350 C

The process is repeated in subsequent cycles, ultimately resulting in a bulge in the hot region and a neck in the adjacent region. This bulging mechanism was very common in the tests by Clauss and Freeman.[9] Concentration of tensile strain in one region and compressive strain in another undoubtedly altered the fatigue characteristics of the material.

3. *Cyclic variation in temperature may, in itself, have an important effect on the material.* For noncubic materials such as zinc and uranium, the effect may be pronounced,[1] while for more conventional structural materials such as steel, the effect may just be present. Avery[11] has, for example, studied a Ni-Cr steel under cyclic-temperature conditions. The highest temperature of the cycle was such that some solution of the carbides into the matrix took place. In general, the smaller particles dissolved first. Upon return to the lower temperatures, the carbides precipitated out again, but instead of precipitating as the fine particles they were before re-solution, they precipitated onto the existing larger carbides which had not dissolved. Thus the larger carbides became even larger. Successive temperature cycling produced an agglomerated carbide structure.

Thus it would be expected that, in some temperature ranges at least, the effect of cyclic variation of temperature could have far different results from those obtained if the temperature were constant at some value intermediate between the highest and lowest temperatures of the cycle.

4. *Superimposed effects of simultaneous variation of temperature and strain are also factors tending to distinguish thermal from mechanical fatigue at constant temperature.* The strain occurs over a spectrum of temperatures, and may therefore have different effects on the microstructural and mechanical properties.

5. *Rates at which mechanical and thermal-stress fatigue tests are conducted generally differ quite greatly.* Since at high temperature, time-dependent creep and microstructural effects become important, considerable difference in fatigue properties may develop, depending on the time cycle involved in the tests.

From the foregoing five points, it can be seen that, although low-cycle mechanical fatigue tests could be useful in interpreting thermal-stress fatigue properties, the differences between the two types of tests are sufficiently great to becloud the correlation, at least in some materials and temperature ranges. It can also be seen that because of the possibility of strain concentration and localization of tensile and compressive strain, the life in thermal fatigue may be less than that in mechanical fatigue for the same average plastic strain per cycle.

The discussion also indicates the desirability of selecting materials for thermal-stress fatigue applications that do not exhibit sharp decreases in yield-point values for small increases in temperature. Alternatively, it points to the desirability of avoiding temperature ranges in which these sharp changes in the yield point can be expected.

▶ Design Applications

Although published data suitable for quantitative analysis are still quite limited, excellent use has been made of these data to answer several questions of practical interest in design.

One problem is the importance of stress concentrations on the life of thermally cycled materials. This problem has been treated[12] for type 347 stainless steel tubes. A test was set up with a tube having a 0.040-in. hole drilled perpendicular to the axis of the tube. With this specimen, reduction in the number of thermal-stress cycles to failure was observed, Fig. 42. To analyze these data, Coffin reasoned that although the elastic stress-concentration factor changes due to plastic flow, the strain-concentration factor remained unaltered. Knowing the uniform strain and the number of cycles to failure, and assuming the localized strain in accordance with the strain-concentration factor, he computed the reduced life of the tube with the hole.

Three types of calculations were made and curves, Fig. 42, plotted for each. For curve *C*, it was assumed that the total inelastic strain, sum of tensile and compressive strain without regard for sign, remained constant. Although good results were obtained, it should be recognized that the basic assumption is rather poor. For example, Fig. 43 shows that the total plastic strain can vary by a factor of 5, depending on the strain per cycle for the annealed material. Under cyclic loading, the total plastic strain encountered can exceed 10,000 per cent.

Calculations for curves *A* and *B*, Fig. 42, were based on the assumption that plastic strain governs fatigue, and that the quantitative relation is the form of Equation 11.[3] In the calculation of *A*, the constants for the equation were based on thermal-streses fatigue data, and in calculation of *B*, constants were based on constant temperature stress-fatigue data.[13] The main conclusion to be drawn from Fig. 42 is that, by refinement in assumptions, it appears possible to predict to reasonable accuracy thermal-stress fatigue in a complex case.

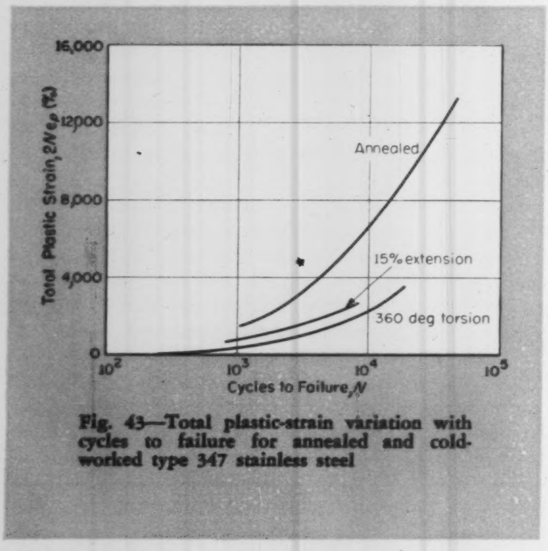

Fig. 43—Total plastic-strain variation with cycles to failure for annealed and cold-worked type 347 stainless steel

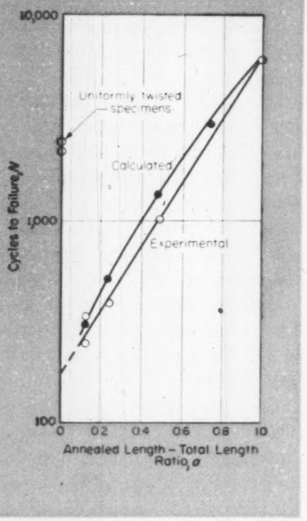

Fig. 44—Cycles to failure of cold-worked type 347 stainless steel with localized annealing. Mean cycle temperature was 350 C with 1 per cent change in strain

Another interesting study was made on the effect of inhomogeneities in introducing strain concentration.[13] In this experiment, the specimen was strain hardened everywhere except along a fraction *a* (ratio of annealed length to total length) at its center. The specimen was then strain cycled at a constant temperature of 350 C, and the number of cycles to cause failure was observed. Also, with Equation 11, the number of cycles to failure was calculated.

It can be seen, Fig. 44, that as the annealed or nonstrain-hardened section approached zero, the number of cycles to failure approached approximately 200, whereas for the uniformly twisted specimens containing no annealed section at all, the number of cycles to failure was over 2000. Thus the presence of a small inhomogeneity in the form of a soft spot causes a drastic reduction in the number of cycles to failure. This presumably takes place because a large fraction of the imposed strain becomes concentrated in the weak inhomogeneity instead of being uniformly distributed along the entire specimen.

Although this experiment related to a specimen at uniform temperature, the implications regarding thermal stress are evident. Thermal gradients may result in local softening and attendant localization of strain, as already discussed.

Work on high-temperature piping has also been a valuable contribution by Coffin. As already indicated, his principal objectives were to determine whether tension at the high temperature produced results differing from those with compression, and to obtain some data under partial constraint. A

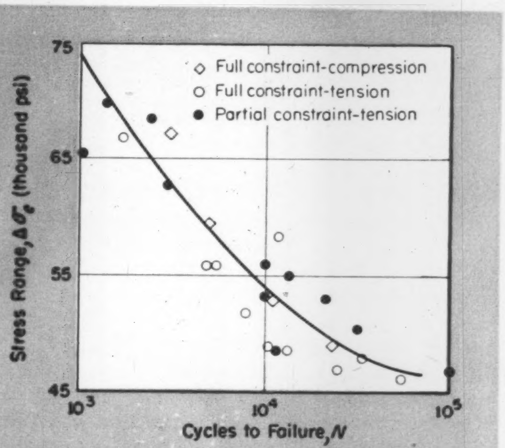

Fig. 45—Correlation of high temperature thermal-cycling behavior of type 347 stainless steel in elastic-stress range. Stress range was computed at 1000 cycles

supplementary objective was to check whether the data could be correlated on the basis of elastic stress range commonly used in design. Fig. 45 shows the results of such a correlation using data for complete and for partial constraint. Both compression and tension were applied at the elevated temperature.

Although there is some scatter, the correlation is quite good, despite the fact that in the correlation of data for full constraint and partial constraint with mechanical strain range, Fig. 30,[4] a definite distinction occurred between the two types of data. A possible explanation for the usefulness of elastic-stress range in thermal-fatigue design will be presented in a later section.

Summary on Ductile Materials

When cyclic plastic strains are induced by constraint of thermal expansion, fatigue ultimately results. Number of cycles that can be withstood depends on the plastic strain, and the temperature at which these strains are induced. Whether tension or compression occurs at the high temperature seems to have little effect on life.

Probably the most important single variable is the maximum temperature of the cycle, particularly if it is high enough to cause metallurgical effects to take place. Increasing the maximum temperature, for a given temperature range, will generally cause a much greater reduction in cycles to failure than increasing the temperature range by the same amount and maintaining the same maximum temperature.

The time at which the maximum temperature is maintained can also have an effect on life, but of smaller magnitude. The effect can also be either beneficial or detrimental to life, depending on the material, temperature, and life range.

Thermal-stress fatigue is quite analogous to mechanical fatigue, and preliminary indications are that both are governed by similar mathematical relations. Because of the continuously changing temperature during a thermal-stress fatigue test, and because of strain concentration and localization effects, it is difficult in some cases to predict life in thermal fatigue from life in mechanical fatigue at constant temperature.

Limited data developed to date indicate that life in a thermal-fatigue test may be considerably less than the life of a mechanically strain-cycled specimen. This is true when the mechanical test is conducted at a constant temperature equal to the average temperature of the thermal-stress fatigue test, and both specimens have the same average strain induced. Several distinguishing features between the two types of fatigue have already been suggested; others may become evident in further investigation.

The effect of prior thermal-stress cycling on specimens subsequently evaluated in stress-rupture depends greatly on the material and the number of prior cycles. In general, the effect can be expected to be detrimental; however, in some cases it may actually be beneficial. For a precipitation-hardened material such as S-816, in which further aging can produce beneficial effects, a small number of thermal-stress cycles increases resistance to stress rupture.

Each of the materials that have been studied to date—type 347 stainless steel, the cobalt-base alloy S-816, and the nickel-base alloys Inconel and Inconel 550—displays characteristics considerably different from the others in thermal-stress fatigue, and prediction of the behavior of one from that of another is difficult. Hence, more classes of materials must be investigated before a reasonably complete picture of the thermal-fatigue behavior of materials in general can be understood.

The next article in this series will present aspects of elastic-range stress computations.

REFERENCES

This article is the fifth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Appraisal of Brittle Materials" .... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" .. June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" August 7, 1958
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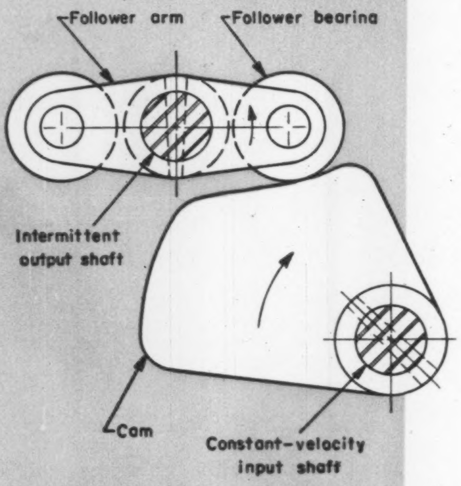
Development of a High-Speed Indexing Mechanism

Design approach and details for a unique cam-based intermittent-motion unit that can be readily adapted to varying acceleration and operating requirements

By RAY C. JOHNSON*
Assistant Professor of Mechanical Engineering
Yale University
New Haven, Conn.

Fig. 1—Typical cam and follower linkage for high-speed indexing unit.



HIGH-SPEED indexing is often a demanding problem that requires more than ordinary measures for design solution. Such a situation was recently encountered in the design of a mechanism for intermittently rotating a given inertia load at a high rate of speed. The inertia load was equivalent in size to a solid aluminum disc 3 in. in diameter and ⅝ in. thick. It was desired to rotate this disc through 0.1 revolution for each index, the ratio of indexing time to zero velocity dwell time being approximately unity. Maximum rate of indexing sought was 3000 complete stops and starts per minute, and the desired normal running speed was 40 complete stops and starts per second. In addition to these requirements, the following characteristics were desired:

1. Life length to be at least 100 million complete stops and starts at a rate of at least 40 indexes per second with no maintenance or replacement of parts.
2. Positional accuracy of the inertia load to be within 5 minutes of correct angular positions.
3. Rotational vibrations of inertia load to be less than 2 minutes, peak to peak amplitude.
4. Designer to have maximum possible control of the acceleration characteristics for the inertia load.
5. Wearable parts to be simple, and easy to replace after 100 million cycles if wear is evident at that time.

An indexing mechanism designed to fulfill these requirements is discussed in this article.

Mechanism Details: For this indexing mechanism, five identical cams are spaced at equal angular intervals on a constant-velocity cam shaft. Each cam has a follower arm which is pinned to the intermittent output shaft, and each arm has a follower ball bearing mounted on each end. One of these cam linkages is illustrated in Fig. 1. Each cam successively contacts its follower during one-fifth of a revolution of the cam shaft, indexing that follower through one-tenth of a revolution. The cams for this particular mechanism are so designed as to give equal intervals for the dwell and indexing throw. A unique feature of this mechanism is that if the output shaft indexes at a fast rate of 3000 cycles per min, the constant-velocity drive shaft only rotates at the relatively slow rate of 600 rpm.

Contact is maintained between the cams and followers by means of a spring torque exerted by helical springs, Fig. 2. The helical pinion on the constant-velocity cam shaft drives the helical gear.

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*Formerly Senior Design Engineer, Eastman Kodak Co., Rochester, N. Y.

which is free wheeling but concentric to the intermittent output shaft. This gear rotates at constant velocity equal to the average angular velocity of the intermittent output shaft. Hence, the springs are intermittently stretched, and the maximum spring torque is supplied to the intermittent shaft when its deceleration is the greatest, a desirable condition. Since tension is maintained in the helical springs at all times and since the gear rotates at constant velocity, it is interesting to notice that the torque exerted on the gear is always in one direction, eliminating the possibility of excessive wear due to backlash.

In Fig. 3, the indexing mechanism is at rest with the cover removed. The inertia disc is shown on the output shaft. Four of the five identical cams can be seen in the picture with contact only between the farthest cam and its follower for the position shown.

High-speed motion pictures were taken of the indexing mechanism while it was operating at a rate of 3000 cycles per min (the motion-picture camera was operating at approximately 2000 pictures per sec). The movies show that the cams and followers move in a smooth manner and maintain proper contact. No vibrations can be detected by the eye. Likewise, the helical springs give smooth motion, also free from any apparent vibrations. Also, the movies show that the output inertia load indexes with a smooth motion, and the accuracy of index is within the specified range as indicated by a 0.002-in. hairline.

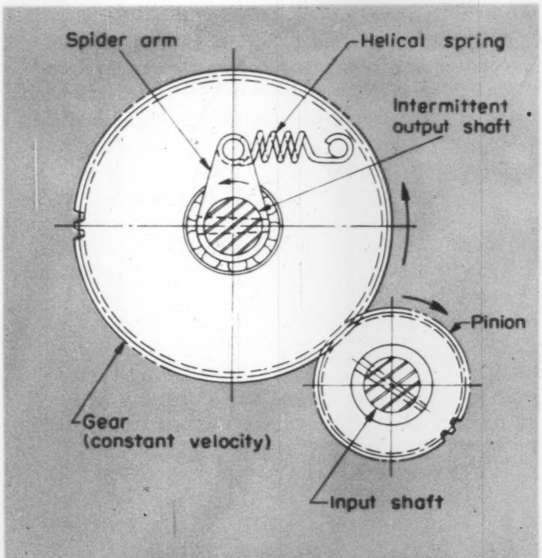
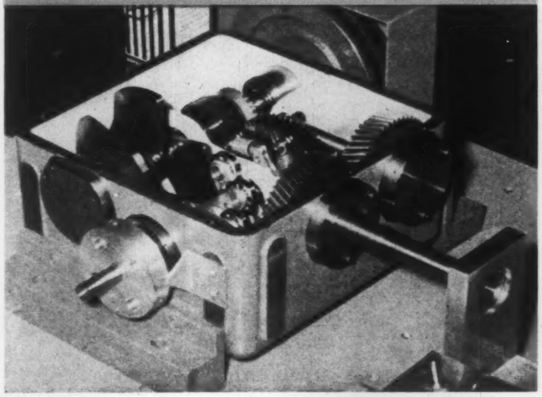


Fig. 2 — Above — Method for supplying spring torque to intermittent shaft.

Fig. 3 — Below — High-speed indexing mechanism at rest with cover removed.



The results from the high-speed motion pictures are very encouraging. However, it should be emphasized that such an analysis only indicates smoothness from a displacement aspect. Since the human eye is a rather poor differentiator, we do not have any indication of the acceleration smoothness at this time. From a force standpoint, the acceleration variation is important. Results of accelerometer measurements will be presented later.

Performance Characteristics: An intermittent mechanism of this type has several advantages for high-speed operation:

1. Members of the mechanism which move intermittently are all near the axis of rotation. Hence, its internal inertia is inherently relatively low.
2. The designer has complete control over the acceleration characteristics as a result of the freedom permitted in the cam design.
3. The designer has choice for the ratio of dwell period to indexing period. This ratio may be varied in design between 0 and approximately 1½ with no difficulty.
4. The input shaft rotates at only one-fifth the rate of intermittency. All shafts rotate at relatively low speeds which is favorable from vibration and wear standpoints.
5. The wear is distributed over five cams and ten follower ball bearings, rather than being concentrated on one driving element.
6. The cam and follower contact is characterized by no backlash and semirolling contact. This is favorable from a wear standpoint.
7. The use of identical cams and springs, and low-cost standard ball bearings for the followers, is favorable from manufacturing and replacement standpoints.

Design Considerations: In the design of this mechanism, many design decisions had to be made. Let us briefly consider some of these.

SELECTION OF MATERIALS: The five identical cams were made from Nitralloy 135 steel with a surface hardness of Rockwell C 70 and a case depth of 0.012 in. This material was desirable from a wear and contact-vibration standpoint. The cams were finish ground after heat treatment using a 2.5 times master cam.

The intermittent follower arms were made from 2024-T aluminum plate because of the low inertia possibilities. Also, the modulus of elasticity of this material is high enough to permit a design having an acceptable degree of stiffness.

The helical springs were made from music wire which was shot peened for longer life. A maximum shear stress of 75,800 psi is reached for every cycle of operation, and in over 153-million cycles of operation, none of the ten springs have failed.

Motion Development: The cam-motion development was made using the theory of finite differences.[1] A cam-angle interval of 1 degree was chosen for calculating the follower-body displacement values. Such an interval is not unreasonably large from a primary acceleration standpoint, and yet is large enough to give tolerable secondary-acceleration fluctuations due to machining errors.[1, 2] The initial follower-body displacement values were obtained from a constant-acceleration solution to the problem, since it always results in a minimum amplitude for the primary acceleration. From the theory of finite differences and the rapid method for motion development,[3] the final fol-

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[1] References are tabulated at end of article.

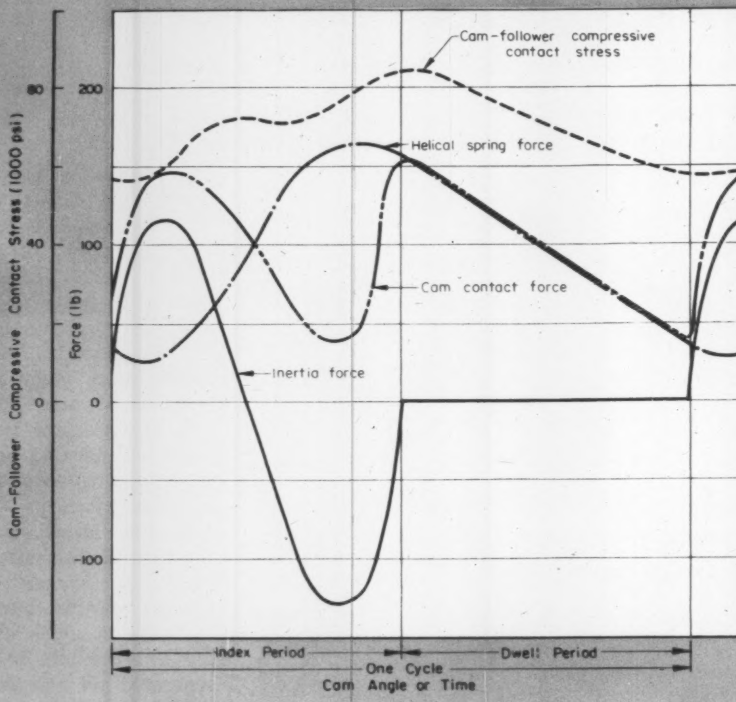
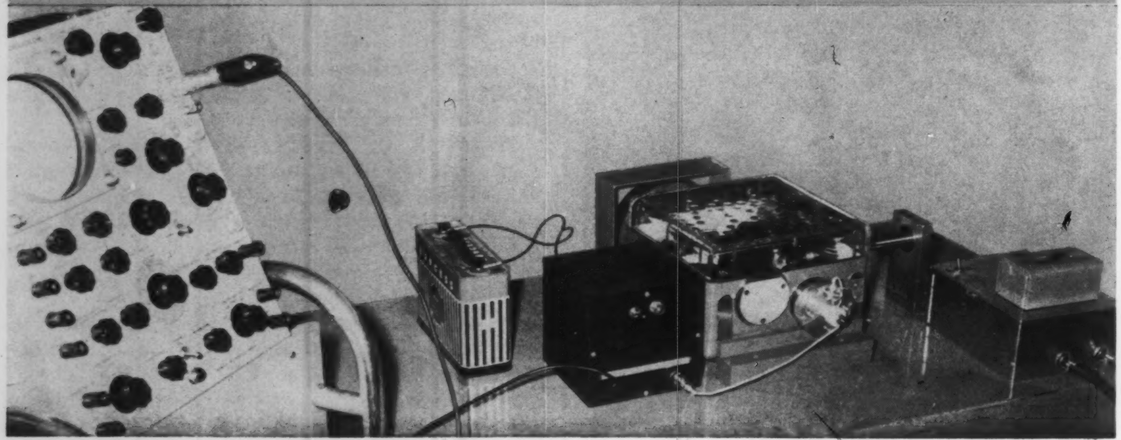


Fig. 4—Dynamic performance summary for high-speed indexing mechanism. All forces are referred to follower bearing axis.

Fig. 5—Below—Instrumentation set-up for measurement of acceleration characteristics of high-speed indexing mechanism. Accelerometer is mounted to the inertia disc on the output shaft.



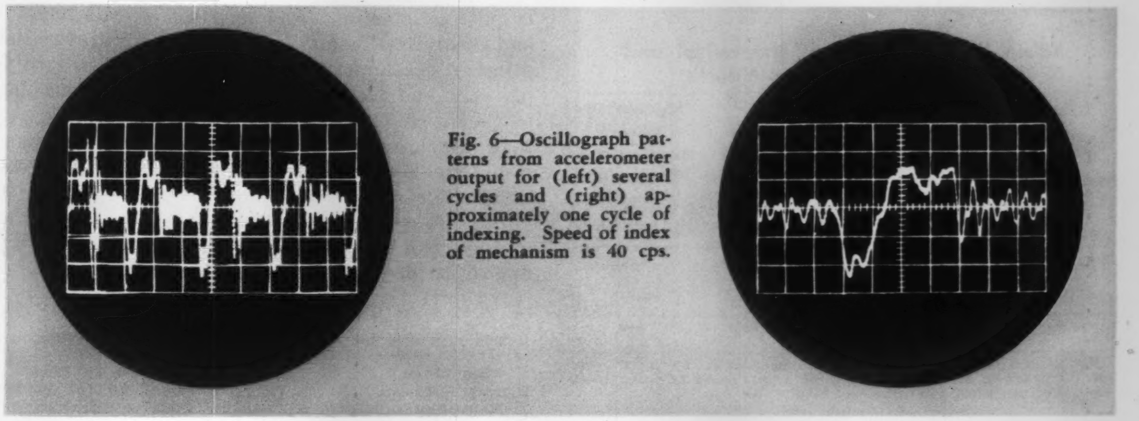


Fig. 6—Oscillograph patterns from accelerometer output for (left) several cycles and (right) approximately one cycle of indexing. Speed of index of mechanism is 40 cps.

lower-body displacement values were calculated so as to give a follower and cam contact force which is low in magnitude and smooth in shape. This is a desirable condition from a contact vibrational standpoint.[4] Based on an assumed acceleration coefficient of 4.00 for a constant-acceleration solution to the problem and 6.28 for a cycloidal-motion solution, the coefficient for the developed motion was 5.00 for the maximum acceleration. If a ten-station Geneva mechanism performed the desired indexing, a maximum acceleration coefficient of 5.95 would exist with the inherently poor acceleration characteristics and high sliding velocities.

Follower and Cam Proportions: The geometric proportions for the follower arms were determined by minimizing the cam contact force. It is easy to see that if the follower arms are too large, the contact force will be large because of the large inertia. On the other hand, if the follower arms are too small, the contact force will be large because of the small torque radius for driving the intermittent shaft. Of course, this is only true for a fixed-output inertia load, which is the situation for this problem. The cam contact force was minimized instead of the cam contact stress,[5] since for this particular problem it was found that the load rating on the ball bearings was more critical than the cam contact stress.

The diameter for the cams was chosen as large as possible without exceeding the catalog load ratings of the follower ball bearings. This is advantageous from a contact stress standpoint.[5]

Dynamic Summary: The dynamic force, stress, and follower motion variations for the mechanism are shown in Fig. 4.

Additional Considerations: Many other factors had to be considered in the design of this mechanism.

Torsional and lateral beam vibrations of both the cam shaft and the output intermittent shaft had to be taken into account. The angular positions of the cams on the cam shaft were staggered to give the best dynamic balance. Also, the widely varying torque on the cam shaft required the use of a flywheel on that shaft.

The drive motor selected had to be capable of exerting the large starting torque required of this mechanism due to the stretching of the helical springs. However, under normal operation, an exchange of energy takes place between the springs and the intermittent inertias, resulting in a theoretical net power consumption of zero. The helical gearing had to be designed properly to accommodate the large and varying torque due to the intermittent stretching of the springs. A 300-sec turbine-oil lubricant was selected to withstand the fairly high contact stresses. The springs had to be checked for internal surgings.

Performance Analysis: The high-speed motion pictures show that the indexing mechanism is satisfactory from a displacement standpoint. However, the apparently smooth indexing motion from a displacement aspect might not be so smooth from an acceleration standpoint.

An accelerometer was mounted on the inertia disc of the mechanism, and its output was fed

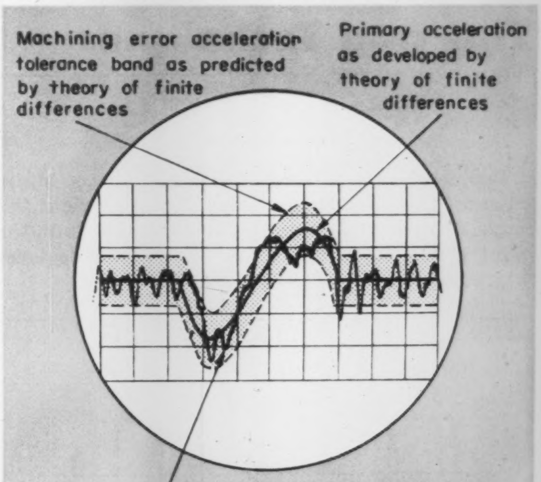


Fig. 7—Comparison of accelerometer measurements (Fig. 6) with acceleration curve developed by method of finite differences.

Table 1—Comparison of Theoretical and Measured Acceleration Values*

Method of Analysis	Maximum Primary Acceleration $A_{0\,max}$ (in. per sec^2)	Machining Error Acceleration Fluctuation A_t (in. per sec^2)
Theory of finite differences	24,700	9,960
Accelerometer measurements	25,800	10,800
Difference	5%	8%

*All accelerations are the tangential component on the inertia disc of the indexing shaft at a radius of 1 in. Speed of index is 40 cps. For graphical comparison of results, see Fig. 7.

through a cathode follower to the oscilloscope, Fig. 5. To avoid the additional inertia and electrical contact difficulties of slip rings, the shielded wire from the accelerometer was wrapped around the indexing shaft, unwinding itself during operation of the mechanism. With this type of a set-up, it was possible to bring the mechanism to a speed of 40 indexes per sec and maintain that rate for several seconds, during which time a photograph was made of the acceleration variation on the oscilloscope.

The acceleration variation for several cycles and slightly more than one cycle is shown in the oscillograph photographs of Fig. 6. A negative print for one cycle is shown in Fig. 7 along with the superimposed primary acceleration variation and machining error tolerance band as obtained by the method of finite differences. As is evidenced in Fig. 7, the correlation between the accelerometer measurements and the finite difference predictions is quite satisfactory. A comparison of experimental and theoretical results is given in Table 1. For the primary acceleration, the correlation is within 5 per cent and for the acceleration fluctuations due to the machining errors, within 8 per cent.

In conclusion, the high-speed indexing mechanism has now been operating under loaded conditions for over 153 million cycles at a rate of 40 to 45 cps with no mechanical failures. The springs, ball bearings, cam surfaces, and gear teeth appear to be withstanding the loads very well.

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2. "Cam Dynamics," Vol. 29, No. 3, February 7, 1957, pp. 105-108.
3. "Cam Profiles," Vol. 28, No. 25, December 13, 1956, pp. 129-132.
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A Mechanisms Conference Paper

This article was presented as a paper at the Fourth Conference on Mechanisms, Purdue University, October 14-15, 1957. These Conferences are cosponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN.

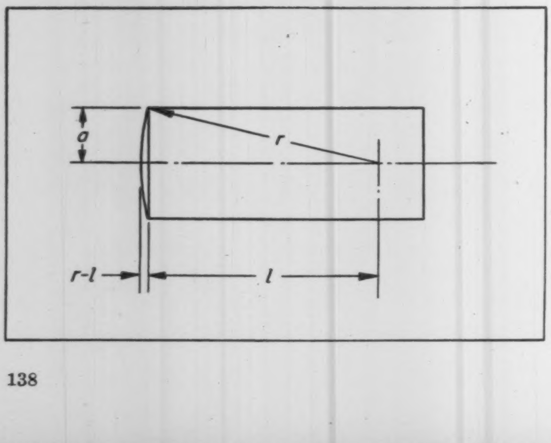
Transactions containing the 13 papers (104 pages) presented at the Conference are available at $2.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio (or see Page 169).

The Fifth Conference on Mechanisms will be held at Purdue University, Lafayette, Ind., October 13 and 14, 1958.

Tips and Techniques

Small Triangles

Frequently a need arises for the difference in hypotenuse and long side lengths of a long, right triangle. In a typical example, the distance l from the pivot point to the end of the lever and the lever width $2a$ are known.



The distance r, which is the clearance necessary to swing the lever, can be determined from the relationship, $r^2 = a^2 + l^2$, as follows:

$$a^2 = r^2 - l^2$$

which by factoring and rearrangement becomes

$$r - l = \frac{a^2}{r + l}$$

For long right triangles, r and l are practically equal, so a substitution of $2\,l$ can be made for $r + l$. Hence, the value for r becomes

$$r = \frac{a^2}{2l} + l$$

This approximation may be used without introducing serious error when the small angle of the triangle is less than 15 degrees. As examples, the error for an 11 degree angle is 1 per cent and for a 30 degree angle is 8 per cent.—ROBERT A. MORGAN, *Pasadena, Calif.*

Tables and equations simplify design of

Conical-Disc Springs

for large loads and small deflections

By EARLWOOD T. FORTINI
Mechanical Engineer
Photon Inc.
Cambridge, Mass.

CONICAL-DISC springs or, as they are sometimes called, Belleville springs, offer two practical attributes in design: Simplicity and compactness. They are ideally suited for spring service where high load over a relatively short range of deflection is required. By suitable choice of spring proportions, wide variation in load-deflection characteristics can be obtained. Moreover, these spring forms can be readily used in combination or in nests to produce many desirable relationships not possible or practical with single springs.

Basic design equations for conical-disc springs[1] are summarized for reference in Table 1 (Symbols are defined in Nomenclature). However, calculations involved in the application of these equations require trial and error procedures which are apt to be time-consuming, considering the essential simplicity of this spring form.

This article presents a simplified design approach, employing modified forms of the equations in Table 1. Design calculations are based on the evaluation of two coefficients. One coefficient depends on the choice of material and working stress, the other on selection of spring proportions. Tables of numerical values for these coefficients are provided. Consideration is also given to load-deflection relationships and to the use of single or multiple-spring assemblies as energy storage devices.

Terminology: Conical-disc springs, as the term is used here, are initially coned, uniform-section, disc springs. Their geometry, Fig. 1, is established by four dimensions: *D, d, h,* and *t.*

Spring elements of this general form are often identified as Belleville springs. However, as defined by Julien Belleville in a U. S. Patent issued in 1867, this designation holds only for conical-disc springs designed to deflect to solid height without permanent set and to have a value of $h/t \leqq 1.25$.

Load-Deflection Characteristics: In the basic load-deflection equation, Table 1, setting $\delta = h$ gives

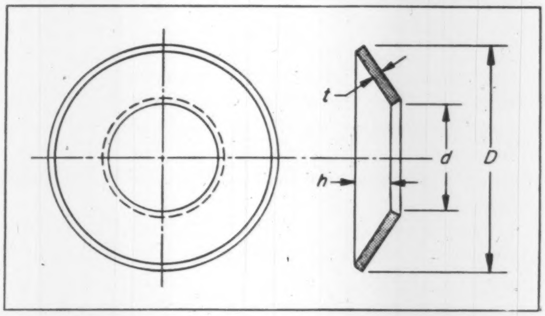


Fig. 1—Geometry of the conical-disc spring

Nomenclature

A = Coefficients dependent upon spring material and working stress (Table 2)
B = Coefficients dependent upon spring proportions (Table 3)
C_1, C_2 = Dimensionless coefficients (Table 1)
D = Outside diameter of spring (Fig. 1), in.
d = Inside diameter of spring (Fig. 1), in.
E = Modulus of elasticity of spring material, psi
h = Free height of spring (Fig. 1), in.
k = Deflection ratio
= δ/h
M = Dimensionless coefficient (Table 1)
P = Applied load at any deflection, lb
P_h = Load required to deflect spring to flat or solid height, lb
s = Working stress, psi
t = Thickness of spring material (Fig. 1), in.
U = Dimensionless value of stored spring energy
V = Stored spring energy, in.-lb
δ = Spring deflection from free height, in.
ν = Poisson's ratio

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[1] References are tabulated at end of article.

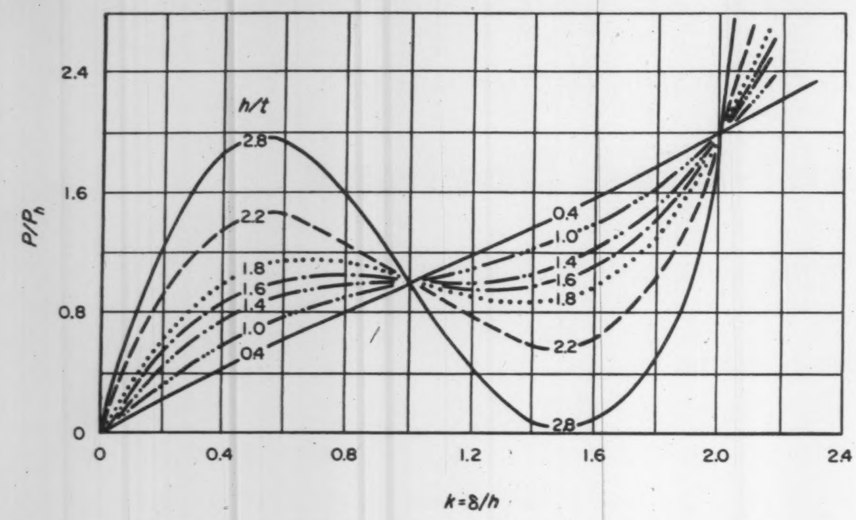

Fig. 2 — Load-deflection characteristics of conical-disc springs plotted in dimensionless form for different values of ratio h/t

the load, P_h, required to deflect a conical-disc spring to flat or solid height:

$$P_h = \frac{h}{t}\,\frac{t^4}{D^2}\,\frac{4E}{(1-\nu^2)M} \tag{1}$$

Dividing the basic equation by this expression gives

$$\frac{P}{P_h} = k + \frac{k}{2}\left(\frac{h}{t}\right)^2 (2-k)(1-k) \tag{2}$$

where P/P_h is the ratio of load at any deflection to load at solid height. In Equation 2, this ratio is expressed in terms of two other ratios: 1. Ratio of free height to thickness, h/t. 2. Ratio of any deflection from free height to deflection at solid height, $\delta/h = k$.

Plots of Equation 2, Fig. 2, show how ratio h/t determines the characteristic shape of the load-deflection curve. When $0 < h/t < 1.4$, spring rate is always positive. When $1.4 < h/t < 2.8$, spring rate is negative in the interval from $k = 0.6$ to 1.2. With a positive spring rate, load increases as deflection increases. But with a negative spring rate, load decreases as deflection increases. When $h/t > 2.8$, the conical-disc spring becomes unstable and will snap into a new position if deflected beyond a certain point.

These load-deflection characteristics often can be used to advantage in design. Note that $h/t = 1.6$ will give, within 5 per cent, a spring rate of zero for a large deflection range.

Energy Storage Characteristics: For many applications, interest in a spring or a combination of springs is concerned with the amount of energy that can be stored. In dimensionless form, the stored energy is represented by the area under the load-deflection curve, Fig. 3. This area has the value,

$$U = \frac{k_1^2}{2} + \frac{1}{2}\left(\frac{h}{t}\right)^2\left(k_1^2 - k_1^3 + \frac{k_1^4}{4}\right) \tag{3}$$

where k_1 is the maximum value of deflection ratio k.

Actual energy values can be determined from

$$V = P_h h U \tag{4}$$

Modified Equations: In simplified form, equations relating spring load to spring geometry are:

$$P = A_D B_D D^2 \tag{5a}$$

$$P = A_d B_d d^2 \tag{5b}$$

$$P = A_t B_t t^2 \tag{6a}$$

$$P = A_h B_h h^2 \tag{6b}$$

These expressions were derived from the equations in Table 1. The A coefficients depend only on choice of material and working stress; the B coefficients are functions of ratios h/t, D/d, and $\delta/h = k$. Equations 5a and b are parallel expressions. The same is true for Equations 6a and b. Thus, for design purposes, only one equation of each pair is needed when ratios h/t and D/d are given. However, preferred procedure is to use Equation 5a and

$$t = A_{tD} B_{tD} D \tag{7}$$

which is obtained by combining Equations 5a and 6a.

Combining Equations 4 and 6b leads to a simplified energy expression,

$$V = A_V B_V P^{1.5} \tag{8}$$

Evaluation of Coefficients: Expressions for the evaluation of the A coefficients are given in Table 2. Choice of material establishes applicable values of Poisson's ratio, ν, and modulus E. However, selection of a suitable working stress, s, requires some consideration.

It has been reported[1] that conical-disc springs are found to function satisfactorily with computed stresses of 200,000 to 220,000 psi even though made from steel with a yield point of 120,000 psi. In fact, according to one spring manufacturer, calculated

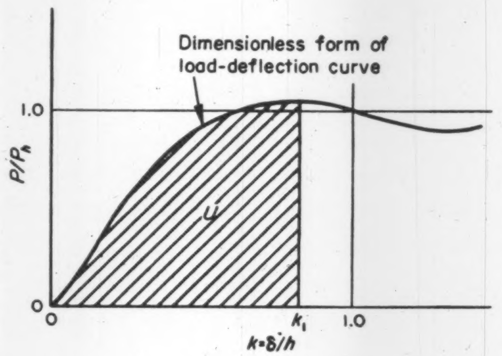

Fig. 3—Dimensionless form of stored energy (*U*) in conical-disc springs. Maximum deflection ratio k_1 defines limit condition

stresses, up to 300,000 psi are not unusual, and that even higher calculated stresses, up to 700,000 psi, can be developed for certain spring proportions. However, high stress values are for static loads and require special precautions such as rounding edges, avoiding surface scratches, etc.

Stress computed with the stress-deflection equa-

Table 1—Basic Design Equations

Load-Deflection

$$P = \frac{4E\delta}{(1-\nu^2)MD^2} \times \left[\left(h-\delta\right)\left(h-\frac{\delta}{2}\right)t + t^3\right]$$

Stress-Deflection*

$$s = \frac{4E\delta}{(1-\nu^2)MD^2}\left[C_1\left(h-\frac{\delta}{2}\right) \pm C_2 t\right]$$

Dimensionless Coefficients

$$M = \frac{6}{\pi \log \frac{D}{d}}\left(\frac{\frac{D}{d}-1}{\frac{D}{d}}\right)^2$$

$$C_1 = \frac{6}{\pi \log \frac{D}{d}}\left(\frac{\frac{D}{d}-1}{\log \frac{D}{d}} - 1\right)$$

$$C_2 = \frac{3\left(\frac{D}{d}-1\right)}{\pi \log \frac{D}{d}}$$

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*For $\delta < 2h$, use positive value of C_2 which will give maximum compressive stress at upper edge of ID. For $\delta > 2h$, use negative value of C_2 which will give maximum tensile stress at lower edge of ID. Compressive stresses have positive values, tensile stresses negative values.

Table 2—Evaluation of Coefficients Dependent Upon Spring Material and Working Stress

Coefficient	Value
A_D, A_d	$\frac{s^2(1-\nu^2)}{4E}$
A_t, A_h	s
A_{tD}	$\left[\frac{s(1-\nu^2)}{4E}\right]^{1/2}$
A_V	$\frac{1}{s^{1/2}}$

Table 3—Evaluation of Coefficients Dependent Upon Spring Proportions*

Coefficient	Value
B_D	$\frac{M\left[\left(\frac{h}{t}\right)^2\left(1-k\right)\left(1-\frac{k}{2}\right)+1\right]}{k\left(\frac{h}{t}\right)\left[C_1\left(\frac{h}{t}\right)\left(1-\frac{k}{2}\right) \pm C_2\right]^2}$
B_d	$B_D\left(\frac{D}{d}\right)^2$
B_t	$\frac{\left(\frac{h}{t}\right)^2\left(1-k\right)\left(1-\frac{k}{2}\right)+1}{C_1\left(\frac{h}{t}\right)\left(1-\frac{k}{2}\right) \pm C_2}$
B_h	$\frac{B_t}{\left(\frac{h}{t}\right)^2}$
B_{tD}	$\left\{\frac{M}{k\left(\frac{h}{t}\right)\left[C_1\left(\frac{h}{t}\right)\left(1-\frac{k}{2}\right) \pm C_2\right]}\right\}^{1/2}$
B_V†	$\frac{U}{{B_{h1}}^{1/2}}$

*Criteria for selection of positive or negative value of C_2 in calculations are given in footnote to Table 1.

†$B_{h1} = B_h$ when $k = 1$.

Table 4—Values of A_D and A_{tD}

s (psi)	A_D	A_{tD}	A_V
Carbon or Alloy Steel ($E = 29 \times 10^6$ psi, $\nu = 0.3$)			
100,000	79	0.0280	0.00316
150,000	177	0.0343	0.00258
200,000	314	0.0396	0.00224
250,000	490	0.0443	0.00200
300,000	707	0.0485	0.00183
Stainless Steel ($E = 28 \times 10^6$ psi, $\nu = 0.3$)			
80,000	52	0.0254	0.00353
100,000	81	0.0284	0.00316
150,000	184	0.0348	0.00258
200,000	326	0.0403	0.00224
250,000	510	0.0450	0.00200
Beryllium Copper ($E = 19 \times 10^6$ psi, $\nu = 0.3$)			
80,000	77	0.0310	0.00353
100,000	120	0.0346	0.00316
150,000	272	0.0424	0.00258
200,000	480	0.0490	0.00224
250,000	750	0.0548	0.00200

Table 5—Values of B_D and B_{tD}

Values of B_D appear in **boldface**   Values of B_{tD} appear in lightface

D/d = 1.2

k	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	**1.670** 1.450	**0.528** 0.784	**0.378** 0.615	**0.325** 0.547	**0.294** 0.497	**0.253** 0.422	**0.207** 0.344
0.50	**0.844** 1.035	**0.249** 0.572	**0.165** 0.447	**0.127** 0.374	**0.125** 0.368	**0.104** 0.314	**0.082** 0.257
0.75	**0.598** 0.870	**0.162** 0.485	**0.098** 0.381	**0.081** 0.344	**0.069** 0.316	**0.053** 0.270	**0.039** 0.224
1.00	**0.475** 0.770	**0.122** 0.436	**0.068** 0.346	**0.053** 0.314	**0.043** 0.290	**0.029** 0.248	**0.017** 0.207
1.25	**0.407** 0.703	**0.105** 0.407	**0.055** 0.327	**0.041** 0.298	**0.031** 0.276	**0.016** 0.238	**0.005** 0.200
1.50	**0.368** 0.655	**0.103** 0.389	**0.056** 0.318	**0.041** 0.282	**0.029** 0.270	**0.013** 0.236	**0.005** 0.200
1.75	**0.343** 0.619	**0.115** 0.384	**0.067** 0.313	**0.052** 0.282	**0.040** 0.270	**0.023** 0.241	**0.008** 0.207
2.00	**0.338** 0.594	**0.135** 0.376	**0.097** 0.318	**0.084** 0.286	**0.075** 0.281	**0.061** 0.252	**0.048** 0.223
2.25	**0.278** 0.545	**0.111** 0.335	**0.082** 0.277	**0.074** 0.256	**0.067** 0.238	**0.060** 0.212	**0.054** 0.184
2.50	**0.239** 0.508	**0.097** 0.320	**0.075** 0.245	**0.069** 0.226	**0.065** 0.210	**0.059** 0.182	**0.053** 0.155

D/d = 1.4

k	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	**2.190** 1.730	**0.706** 0.939	**0.498** 0.730	**0.442** 0.657	**0.394** 0.599	**0.344** 0.508	**0.284** 0.416
0.50	**1.142** 1.250	**0.334** 0.685	**0.222** 0.536	**0.192** 0.486	**0.172** 0.443	**0.141** 0.378	**0.112** 0.310
0.75	**0.796** 1.042	**0.217** 0.580	**0.136** 0.464	**0.109** 0.414	**0.093** 0.380	**0.072** 0.326	**0.053** 0.268
1.00	**0.630** 0.920	**0.164** 0.522	**0.092** 0.416	**0.072** 0.378	**0.058** 0.348	**0.039** 0.300	**0.028** 0.249
1.25	**0.538** 0.840	**0.140** 0.487	**0.074** 0.392	**0.056** 0.358	**0.041** 0.330	**0.022** 0.286	**0.007** 0.241
1.50	**0.487** 0.783	**0.136** 0.466	**0.072** 0.379	**0.054** 0.349	**0.045** 0.324	**0.018** 0.283	**0.006** 0.249
1.75	**0.458** 0.740	**0.152** 0.460	**0.087** 0.376	**0.069** 0.348	**0.053** 0.324	**0.031** 0.285	**0.011** 0.249
2.00	**0.446** 0.710	**0.178** 0.449	**0.127** 0.379	**0.111** 0.355	**0.098** 0.334	**0.080** 0.302	**0.064** 0.268
2.25	**0.370** 0.653	**0.146** 0.400	**0.109** 0.332	**0.098** 0.306	**0.090** 0.286	**0.078** 0.253	**0.071** 0.219
2.50	**0.306** 0.606	**0.128** 0.361	**0.099** 0.293	**0.092** 0.270	**0.086** 0.251	**0.080** 0.219	**0.073** 0.187

D/d = 1.6

k	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	**2.380** 1.960	**0.775** 1.017	**0.552** 0.790	**0.490** 0.715	**0.444** 0.652	**0.382** 0.553	**0.319** 0.453
0.50	**1.248** 1.352	**0.368** 0.744	**0.245** 0.582	**0.212** 0.526	**0.188** 0.481	**0.157** 0.411	**0.125** 0.338
0.75	**0.863** 1.123	**0.238** 0.598	**0.122** 0.496	**0.120** 0.450	**0.103** 0.412	**0.080** 0.353	**0.059** 0.292
1.00	**0.570** 0.908	**0.180** 0.565	**0.101** 0.450	**0.079** 0.410	**0.064** 0.376	**0.043** 0.324	**0.026** 0.270
1.25	**0.508** 0.845	**0.153** 0.527	**0.082** 0.424	**0.061** 0.388	**0.045** 0.358	**0.024** 0.311	**0.008** 0.261
1.50	**0.528** 0.844	**0.148** 0.503	**0.078** 0.410	**0.059** 0.376	**0.042** 0.349	**0.020** 0.306	**0.001** 0.261
1.75	**0.493** 0.795	**0.164** 0.496	**0.094** 0.405	**0.075** 0.375	**0.060** 0.355	**0.034** 0.311	**0.012** 0.268
2.00	**0.428** 0.765	**0.192** 0.484	**0.137** 0.408	**0.120** 0.382	**0.107** 0.360	**0.087** 0.326	**0.069** 0.290
2.25	**0.400** 0.704	**0.158** 0.431	**0.118** 0.358	**0.106** 0.332	**0.098** 0.310	**0.087** 0.274	**0.077** 0.236
2.50	**0.339** 0.654	**0.139** 0.390	**0.109** 0.317	**0.100** 0.292	**0.093** 0.268	**0.087** 0.236	**0.081** 0.202

D/d = 1.8

k	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	**2.425** 1.930	**0.780** 1.050	**0.562** 0.820	**0.496** 0.738	**0.449** 0.672	**0.392** 0.572	**0.323** 0.468
0.50	**1.241** 1.279	**0.372** 0.765	**0.248** 0.600	**0.214** 0.544	**0.189** 0.496	**0.159** 0.424	**0.127** 0.348
0.75	**0.861** 1.158	**0.239** 0.648	**0.149** 0.515	**0.122** 0.465	**0.105** 0.427	**0.081** 0.362	**0.060** 0.302
1.00	**0.681** 1.024	**0.180** 0.583	**0.103** 0.465	**0.079** 0.420	**0.064** 0.388	**0.043** 0.336	**0.027** 0.279
1.25	**0.580** 0.930	**0.155** 0.544	**0.081** 0.437	**0.061** 0.400	**0.047** 0.377	**0.024** 0.321	**0.008** 0.268
1.50	**0.522** 0.870	**0.147** 0.517	**0.079** 0.422	**0.059** 0.388	**0.042** 0.360	**0.020** 0.316	**0.001** 0.268
1.75	**0.488** 0.820	**0.164** 0.510	**0.094** 0.417	**0.075** 0.386	**0.058** 0.360	**0.034** 0.321	**0.001** 0.276
2.00	**0.474** 0.784	**0.190** 0.496	**0.135** 0.419	**0.119** 0.392	**0.105** 0.370	**0.086** 0.334	**0.068** 0.296
2.25	**0.395** 0.724	**0.157** 0.444	**0.117** 0.368	**0.106** 0.340	**0.097** 0.318	**0.087** 0.283	**0.077** 0.243
2.50	**0.326** 0.660	**0.139** 0.401	**0.109** 0.327	**0.101** 0.302	**0.094** 0.279	**0.088** 0.244	**0.080** 0.207

D/d = 2.0

k	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	**2.325** 1.950	**0.760** 1.060	**0.541** 0.825	**0.481** 0.745	**0.411** 0.680	**0.379** 0.578	**0.314** 0.473
0.50	**1.198** 1.405	**0.358** 0.774	**0.240** 0.607	**0.208** 0.550	**0.184** 0.502	**0.154** 0.429	**0.079** 0.314
0.75	**0.830** 1.167	**0.230** 0.654	**0.143** 0.517	**0.118** 0.469	**0.090** 0.418	**0.078** 0.368	**0.059** 0.305
1.00	**0.653** 1.030	**0.168** 0.580	**0.098** 0.472	**0.077** 0.426	**0.062** 0.392	**0.042** 0.339	**0.026** 0.281
1.25	**0.556** 0.939	**0.147** 0.537	**0.078** 0.440	**0.059** 0.404	**0.044** 0.373	**0.024** 0.324	**0.007** 0.272
1.50	**0.498** 0.874	**0.142** 0.522	**0.075** 0.425	**0.057** 0.391	**0.041** 0.363	**0.019** 0.320	**0.001** 0.270
1.75	**0.474** 0.832	**0.157** 0.515	**0.091** 0.420	**0.071** 0.388	**0.056** 0.363	**0.033** 0.324	**0.012** 0.279
2.00	**0.453** 0.790	**0.181** 0.500	**0.129** 0.422	**0.113** 0.394	**0.101** 0.373	**0.083** 0.338	**0.064** 0.298
2.25	**0.378** 0.730	**0.151** 0.447	**0.112** 0.370	**0.102** 0.344	**0.094** 0.321	**0.084** 0.284	**0.075** 0.247
2.50	**0.324** 0.677	**0.134** 0.405	**0.105** 0.330	**0.096** 0.303	**0.090** 0.281	**0.085** 0.247	**0.079** 0.210

D/d = 2.2

k	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	**2.222** 1.955	**0.732** 1.064	**0.525** 0.832	**0.466** 0.750	**0.424** 0.685	**0.370** 0.583	**0.306** 0.477
0.50	**1.140** 1.410	**0.346** 0.777	**0.232** 0.610	**0.201** 0.553	**0.179** 0.505	**0.150** 0.432	**0.121** 0.356
0.75	**0.792** 1.170	**0.222** 0.657	**0.136** 0.519	**0.114** 0.472	**0.088** 0.422	**0.076** 0.371	**0.057** 0.306
1.00	**0.621** 1.060	**0.167** 0.590	**0.095** 0.471	**0.075** 0.430	**0.060** 0.394	**0.041** 0.340	**0.025** 0.284
1.25	**0.529** 0.940	**0.141** 0.550	**0.070** 0.426	**0.057** 0.406	**0.042** 0.374	**0.023** 0.326	**0.007** 0.274
1.50	**0.475** 0.875	**0.135** 0.523	**0.075** 0.428	**0.055** 0.394	**0.039** 0.365	**0.018** 0.320	**0.001** 0.272
1.75	**0.433** 0.826	**0.149** 0.515	**0.086** 0.420	**0.067** 0.387	**0.053** 0.365	**0.031** 0.324	**0.011** 0.279
2.00	**0.427** 0.790	**0.171** 0.500	**0.122** 0.422	**0.108** 0.396	**0.095** 0.372	**0.078** 0.338	**0.061** 0.298
2.25	**0.358** 0.730	**0.143** 0.447	**0.107** 0.372	**0.097** 0.344	**0.089** 0.321	**0.079** 0.284	**0.071** 0.247
2.50	**0.308** 0.680	**0.127** 0.406	**0.099** 0.330	**0.093** 0.305	**0.087** 0.283	**0.082** 0.249	**0.074** 0.210

D/d = 2.4

k	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	**2.070** 1.940	**0.687** 1.054	**0.500** 0.825	**0.442** 0.744	**0.403** 0.680	**0.352** 0.580	**0.292** 0.475
0.50	**1.063** 1.390	**0.324** 0.770	**0.219** 0.607	**0.191** 0.550	**0.169** 0.502	**0.142** 0.429	**0.115** 0.354
0.75	**0.735** 1.158	**0.209** 0.650	**0.129** 0.515	**0.108** 0.468	**0.093** 0.430	**0.072** 0.368	**0.054** 0.305
1.00	**0.598** 1.039	**0.155** 0.583	**0.089** 0.467	**0.070** 0.425	**0.056** 0.391	**0.038** 0.338	**0.023** 0.281
1.25	**0.491** 0.930	**0.132** 0.544	**0.069** 0.438	**0.053** 0.402	**0.039** 0.370	**0.021** 0.322	**0.007** 0.272
1.50	**0.465** 0.864	**0.126** 0.517	**0.070** 0.423	**0.051** 0.388	**0.036** 0.361	**0.017** 0.316	**0.006** 0.270
1.75	**0.410** 0.815	**0.138** 0.508	**0.080** 0.416	**0.063** 0.384	**0.049** 0.359	**0.029** 0.319	**0.010** 0.277
2.00	**0.396** 0.780	**0.158** 0.492	**0.113** 0.417	**0.099** 0.390	**0.088** 0.367	**0.072** 0.333	**0.057** 0.295
2.25	**0.332** 0.720	**0.133** 0.442	**0.100** 0.367	**0.090** 0.340	**0.083** 0.318	**0.075** 0.282	**0.070** 0.251
2.50	**0.284** 0.670	**0.119** 0.401	**0.093** 0.327	**0.087** 0.302	**0.081** 0.279	**0.076** 0.245	**0.070** 0.210

D/d = 2.7

k	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	**1.905** 1.910	**0.638** 1.042	**0.460** 0.815	**0.410** 0.736	**0.373** 0.672	**0.323** 0.571	**0.272** 0.470
0.50	**0.977** 1.372	**0.300** 0.761	**0.203** 0.598	**0.176** 0.542	**0.156** 0.496	**0.133** 0.424	**0.107** 0.349
0.75	**0.674** 1.140	**0.192** 0.642	**0.120** 0.510	**0.100** 0.463	**0.086** 0.424	**0.067** 0.364	**0.048** 0.298
1.00	**0.529** 1.005	**0.144** 0.577	**0.082** 0.460	**0.064** 0.420	**0.052** 0.386	**0.036** 0.334	**0.022** 0.279
1.25	**0.451** 0.915	**0.121** 0.535	**0.065** 0.432	**0.049** 0.396	**0.037** 0.366	**0.021** 0.318	**0.006** 0.268
1.50	**0.403** 0.851	**0.116** 0.511	**0.063** 0.418	**0.041** 0.383	**0.033** 0.356	**0.016** 0.313	**0.001** 0.268
1.75	**0.377** 0.805	**0.130** 0.507	**0.073** 0.410	**0.058** 0.379	**0.046** 0.358	**0.027** 0.316	**0.010** 0.279
2.00	**0.362** 0.768	**0.145** 0.485	**0.104** 0.411	**0.091** 0.385	**0.081** 0.362	**0.066** 0.327	**0.052** 0.290
2.25	**0.304** 0.710	**0.122** 0.436	**0.091** 0.362	**0.082** 0.332	**0.076** 0.313	**0.069** 0.279	**0.061** 0.241
2.50	**0.262** 0.660	**0.109** 0.395	**0.086** 0.322	**0.080** 0.298	**0.075** 0.276	**0.071** 0.243	**0.065** 0.207

Table 5 (Continued)

Values of B_D appear in boldface Values of B_{tD} appear in lightface

D/d = 3.0

k h/t=0.4		1.0	1.4	1.6	1.8	2.2	2.8
0.25	**1.740** 1.870	**0.582** 1.024	**0.424** 0.803	**0.384** 0.730	**0.344** 0.662	**0.302** 0.565	**0.253** 0.463
0.50	**0.885** 1.345	**0.202** 0.748	**0.187** 0.590	**0.162** 0.534	**0.144** 0.487	**0.123** 0.418	**0.099** 0.345
0.75	**0.612** 1.119	**0.175** 0.630	**0.110** 0.500	**0.092** 0.455	**0.079** 0.417	**0.059** 0.351	**0.046** 0.296
1.00	**0.480** 0.990	**0.128** 0.565	**0.075** 0.452	**0.060** 0.414	**0.048** 0.381	**0.033** 0.328	**0.020** 0.274
1.25	**0.407** 0.895	**0.111** 0.526	**0.060** 0.425	**0.045** 0.388	**0.033** 0.359	**0.018** 0.313	**0.006** 0.262
1.50	**0.364** 0.833	**0.105** 0.500	**0.057** 0.410	**0.043** 0.377	**0.031** 0.349	**0.014** 0.308	**0.001** 0.260
1.75	**0.338** 0.788	**0.114** 0.490	**0.066** 0.401	**0.053** 0.372	**0.041** 0.348	**0.025** 0.310	**0.008** 0.268
2.00	**0.328** 0.752	**0.103** 0.475	**0.093** 0.403	**0.081** 0.376	**0.072** 0.355	**0.059** 0.321	**0.047** 0.284
2.25	**0.274** 0.695	**0.110** 0.427	**0.082** 0.353	**0.075** 0.328	**0.069** 0.306	**0.062** 0.272	**0.056** 0.236
2.50	**0.235** 0.645	**0.099** 0.387	**0.078** 0.316	**0.072** 0.292	**0.068** 0.270	**0.065** 0.238	**0.059** 0.202

D/d = 3.5

k h/t=0.4		1.0	1.4	1.6	1.8	2.2	2.8
0.25	**1.488** 1.815	**0.504** 0.993	**0.368** 0.779	**0.328** 0.705	**0.297** 0.640	**0.284** 0.547	**0.222** 0.450
0.50	**0.784** 1.300	**0.236** 0.724	**0.161** 0.570	**0.141** 0.517	**0.125** 0.473	**0.106** 0.406	**0.087** 0.334
0.75	**0.521** 1.079	**0.152** 0.610	**0.095** 0.485	**0.079** 0.440	**0.068** 0.405	**0.054** 0.348	**0.040** 0.288
1.00	**0.409** 0.950	**0.112** 0.547	**0.065** 0.438	**0.051** 0.400	**0.042** 0.368	**0.029** 0.319	**0.018** 0.266
1.25	**0.346** 0.865	**0.111** 0.508	**0.051** 0.411	**0.038** 0.376	**0.028** 0.348	**0.016** 0.303	**0.005** 0.255
1.50	**0.308** 0.803	**0.089** 0.482	**0.048** 0.395	**0.036** 0.363	**0.026** 0.337	**0.012** 0.296	— 0.253
1.75	**0.286** 0.758	**0.097** 0.473	**0.056** 0.387	**0.045** 0.359	**0.035** 0.334	**0.020** 0.298	**0.007** 0.258
2.00	**0.275** 0.724	**0.110** 0.457	**0.078** 0.386	**0.069** 0.362	**0.061** 0.340	**0.050** 0.308	**0.039** 0.274
2.25	**0.231** 0.669	**0.093** 0.411	**0.070** 0.342	**0.064** 0.318	**0.060** 0.296	**0.053** 0.262	**0.047** 0.228
2.50	**0.199** 0.622	**0.084** 0.374	**0.066** 0.305	**0.062** 0.282	**0.059** 0.263	**0.055** 0.230	**0.039** 0.197

D/d = 4.0

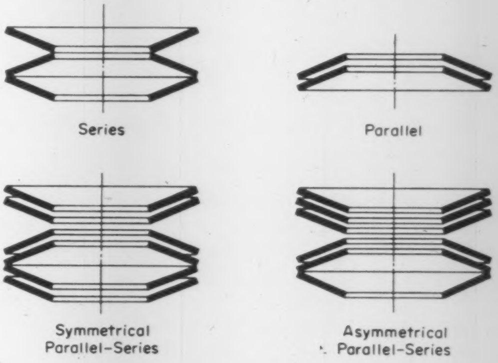
k h/t=0.4		1.0	1.4	1.6	1.8	2.2	2.8
0.25	**1.289** 1.746	**0.444** 0.960	**0.317** 0.752	**0.290** 0.681	**0.265** 0.622	**0.232** 0.531	**0.196** 0.437
0.50	**0.656** 1.252	**0.207** 0.700	**0.142** 0.553	**0.123** 0.500	**0.106** 0.454	**0.094** 0.394	**0.076** 0.324
0.75	**0.452** 1.040	**0.132** 0.590	**0.083** 0.469	**0.070** 0.427	**0.060** 0.391	**0.048** 0.338	**0.036** 0.279
1.00	**0.353** 0.915	**0.098** 0.529	**0.057** 0.424	**0.045** 0.387	**0.036** 0.356	**0.025** 0.308	**0.016** 0.259
1.25	**0.298** 0.833	**0.082** 0.490	**0.045** 0.397	**0.034** 0.363	**0.025** 0.338	**0.014** 0.293	**0.004** 0.247
1.50	**0.265** 0.775	**0.077** 0.476	**0.042** 0.381	**0.032** 0.350	**0.023** 0.327	**0.008** 0.286	— 0.245
1.75	**0.246** 0.730	**0.083** 0.456	**0.049** 0.374	**0.039** 0.346	**0.030** 0.324	**0.018** 0.288	**0.009** 0.248
2.00	**0.236** 0.697	**0.094** 0.440	**0.067** 0.371	**0.059** 0.348	**0.053** 0.328	**0.043** 0.296	**0.034** 0.252
2.25	**0.199** 0.644	**0.080** 0.396	**0.060** 0.328	**0.055** 0.306	**0.051** 0.286	**0.046** 0.254	**0.038** 0.219
2.50	**0.172** 0.600	**0.073** 0.360	**0.059** 0.296	**0.054** 0.272	**0.051** 0.253	**0.048** 0.221	**0.045** 0.189

D/d = 4.5

k h/t=0.4		1.0	1.4	1.6	1.8	2.2	2.8
0.25	**1.108** 1.680	**0.384** 0.929	**0.287** 0.730	**0.252** 0.658	**0.231** 0.601	**0.203** 0.513	**0.172** 0.423
0.50	**0.567** 1.210	**0.179** 0.675	**0.123** 0.534	**0.108** 0.484	**0.096** 0.444	**0.082** 0.381	**0.067** 0.314
0.75	**0.387** 1.000	**0.114** 0.569	**0.072** 0.453	**0.060** 0.412	**0.052** 0.378	**0.041** 0.326	**0.031** 0.270
1.00	**0.304** 0.883	**0.084** 0.510	**0.049** 0.409	**0.039** 0.372	**0.031** 0.343	**0.022** 0.298	**0.014** 0.249
1.25	**0.266** 0.804	**0.071** 0.472	**0.038** 0.382	**0.029** 0.351	**0.022** 0.324	**0.012** 0.283	**0.004** 0.238
1.50	**0.227** 0.745	**0.067** 0.450	**0.036** 0.367	**0.027** 0.339	**0.020** 0.314	**0.009** 0.277	— 0.234
1.75	**0.211** 0.703	**0.072** 0.439	**0.044** 0.359	**0.033** 0.333	**0.026** 0.311	**0.015** 0.277	**0.005** 0.240
2.00	**0.201** 0.669	**0.081** 0.424	**0.057** 0.358	**0.050** 0.334	**0.045** 0.316	**0.037** 0.286	**0.029** 0.253
2.25	**0.170** 0.620	**0.069** 0.380	**0.052** 0.318	**0.047** 0.293	**0.046** 0.281	**0.039** 0.245	**0.035** 0.212
2.50	**0.147** 0.576	**0.063** 0.348	**0.050** 0.284	**0.047** 0.262	**0.044** 0.243	**0.041** 0.214	**0.037** 0.182

D/d = 5.0

k h/t=0.4		1.0	1.4	1.6	1.8	2.2	2.8
0.25	**0.973** 1.620	**0.339** 0.896	**0.270** 0.705	**0.225** 0.639	**0.206** 0.584	**0.182** 0.498	**0.154** 0.410
0.50	**0.495** 1.164	**0.159** 0.653	**0.109** 0.515	**0.095** 0.468	**0.085** 0.429	**0.073** 0.368	**0.060** 0.303
0.75	**0.340** 0.965	**0.101** 0.550	**0.064** 0.438	**0.054** 0.398	**0.046** 0.366	**0.036** 0.314	**0.028** 0.262
1.00	**0.266** 0.850	**0.074** 0.491	**0.043** 0.395	**0.034** 0.360	**0.028** 0.333	**0.019** 0.286	**0.015** 0.241
1.25	**0.223** 0.772	**0.062** 0.456	**0.034** 0.368	**0.026** 0.339	**0.019** 0.313	**0.008** 0.274	**0.003** 0.230
1.50	**0.198** 0.718	**0.059** 0.431	**0.032** 0.355	**0.024** 0.327	**0.017** 0.304	**0.008** 0.268	— 0.228
1.75	**0.184** 0.678	**0.063** 0.423	**0.036** 0.346	**0.028** 0.320	**0.023** 0.300	**0.013** 0.266	**0.005** 0.232
2.00	**0.175** 0.645	**0.070** 0.408	**0.050** 0.345	**0.044** 0.322	**0.038** 0.302	**0.032** 0.276	**0.025** 0.243
2.25	**0.148** 0.596	**0.060** 0.368	**0.045** 0.305	**0.040** 0.282	**0.038** 0.264	**0.035** 0.236	**0.031** 0.205
2.50	**0.129** 0.556	**0.055** 0.334	**0.044** 0.274	**0.041** 0.253	**0.038** 0.234	**0.037** 0.207	**0.047** 0.176



Series

Parallel

Symmetrical Parallel-Series

Asymmetrical Parallel-Series

Fig. 4—Types of conical-disc spring nests

Table 6—Dimensionless Values of Stored Energy

	Dimensionless Energy Value, U						
k_1	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
0.25	0.0350	0.0562	0.0781	0.0925	0.1087	0.1472	0.2192
0.50	0.1363	0.1953	0.2622	0.3050	0.3525	0.4650	0.6750
0.75	0.2988	0.3907	0.4985	0.5622	0.6372	0.8132	1.1412
1.00	0.5200	0.6250	0.7450	0.8200	0.9050	1.1050	1.4800
1.25	0.7988	0.8907	0.9985	1.0622	1.1372	1.3132	1.6412
1.50	1.1363	1.1953	1.2622	1.3050	1.3525	1.4650	1.6750
1.75	1.5350	1.5561	1.5781	1.5925	1.6087	1.6472	1.7192
2.00	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
2.25	2.5375	2.8705	2.6082	2.6317	2.6583	2.7212	2.8392
2.50	3.1562	3.3200	3.5070	3.6250	3.7570	4.0700	4.6550

Table 7—Values of $1/B_{h1}^{1/2}$

D/d	h/t=0.4	1.0	1.4	1.6	1.8	2.2	2.8
1.2	0.447	1.230	1.851	2.172	2.520	3.235	4.400
1.4	0.469	1.290	1.920	2.259	2.600	3.342	4.540
1.6	0.482	1.335	1.982	2.330	2.685	3.460	4.670
1.8	0.495	1.360	2.040	2.390	2.765	3.540	4.800
2.0	0.510	1.410	2.095	2.455	2.840	3.630	4.930
2.2	0.523	1.445	2.140	2.510	2.920	3.720	5.040
2.4	0.538	1.480	2.195	2.570	2.970	3.785	5.140
2.7	0.552	1.520	2.258	2.640	3.025	3.920	5.260
3.0	0.568	1.560	2.310	2.760	3.135	4.000	5.400
3.5	0.595	1.635	2.410	2.820	3.260	4.160	5.630
4.0	0.616	1.690	2.495	2.920	3.370	4.300	5.800
4.5	0.640	1.750	2.590	3.020	3.500	4.460	6.000
5.0	0.660	1.805	2.660	3.115	3.590	4.580	6.170

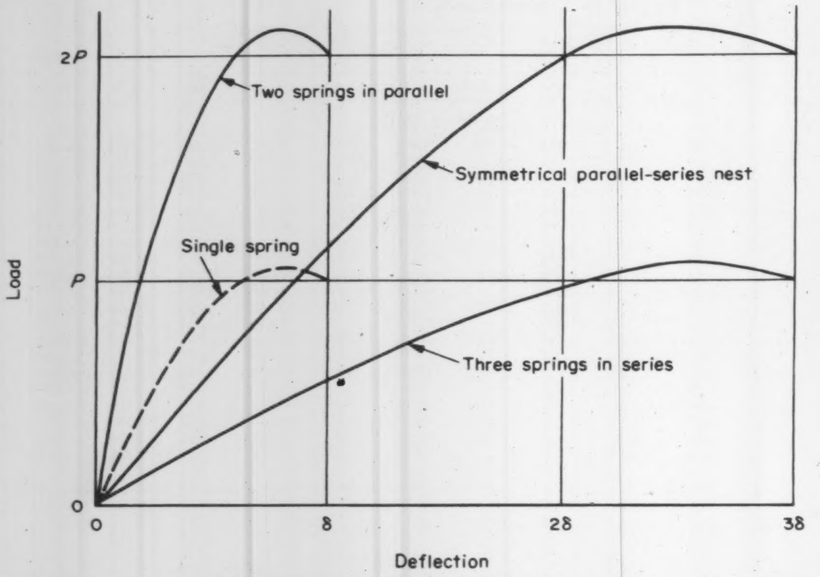


Fig. 5 — Comparative load-deflection characteristics for single and multiple conical-disc spring assemblies. Plots for spring nests are based on combinations shown in Fig. 4

tion in Table 1 is located on the inside diameter of a conical-disc spring. Compressive stress is indicated by a positive value, tensile stress by a negative value. Also, when a positive value of coefficient C_2 is used for calculations, the stress found is for the upper edge; when C_2 is negative, the stress value is referred to the lower edge.

The stress-deflection equation (Table 1) can be put into the form,

$$s = \frac{4E}{(1-\nu^2)B_{tD}^2}\left(\frac{t}{D}\right)^2 \qquad (9)$$

where coefficient B_{tD} is defined in Table 3. Ratio t/D is, of course, uniquely determined by (1) the spring material, (2) ratios D/d and h/t and (3) the value of stress corresponding to some maximum relative deflection, k.

Information given here on stresses in conical-disc springs is necessarily limited. Further discussion can be found in the literature.[2]

Numerical values of the A coefficients for various combinations of materials and working stresses are given in Table 4.

Equations for the B coefficients are given in Table 3. These coefficients, as mentioned previously, are functions of h/t, D/d, and k. Effect of ratio h/t on load-deflection characteristics has been discussed. Choice of ratio D/d is often limited by design considerations quite apart from spring requirements. Size and space, or weight, limitations may leave little if any choice. Values of D/d between 1.4 and 3 are recommended, although it is possible to use other proportions. When $D/d = 1.8$, maximum load for a given outside diameter is obtained. In the absence of other considerations, this proportion should be used.

A conical-disc spring should be designed so that at maximum deflection the spring will not take a permanent set. Deflections greater than twice the free height ($k > 2$) are possible; however, for most applications, deflection beyond solid height is not desirable. Even when deflection beyond solid height is not necessary, it is often good practice to base design on stress at deflection to solid height ($k = 1$) as a criterion.

When evaluating the B coefficients, Table 3, positive values of C_2 should be used for $k \leqq 2$, negative values for $k > 2$. Values of B_D and B_{tD}, calculated to slide-rule accuracy for different values of D/d, h/t, and k, are given in Table 5.

For simplified energy calculations (Equation 8), numerical values of U are given in Table 6, values of $1/B_{h1}^{1/2}$ in Table 7. Product of the values (Table 3) gives B_V.

Nests of Springs: Combining conical-disc springs in nests greatly increases their range of application. The two basic ways of grouping springs, Fig. 4, are (1) in series and (2) in parallel. Symmetrical and asymmetrical combinations of these basic arrangements are also possible, Fig. 4.

Load-deflection characteristics of nests of springs are derived from the characteristics of the individual elements. For springs in series, the deflection scale (deflection per unit load) of the individual spring is multiplied by the number of series elements. For springs in parallel the load scale or gradient (load per unit deflection) is multiplied by the number of springs in the parallel group. For symmetrical parallel-series nests, values of load and deflection scales are simply multiples of values of individual springs. For example, in Fig. 4, the deflection scale of the symmetrical parallel-series nest is three times that of an individual spring, and the load scale is two times the individual value. Fig. 5 illustrates how load-deflection characteristics for combinations differ-from those of a single spring.

Load-deflection characteristics of asymmetrical nests may be worked out by superposition.

Energy stored in symmetrical nests can be found by multiplying the energy stored in a single spring by the number of springs in the nest. To find the energy stored in asymmetrical nests, the area under the load-deflection curve is determined by graphical integration.

Design Calculations: Factors that influence design of conical-disc springs as load-carrying elements fall into three groups:

(1) Range of load-deflection values.
(2) Choice of material and working stress.
(3) Spring proportions and size.

With the simplified equations and tables of coefficient values provided here, a number of possible solutions to spring-design problems can be quickly worked out. The form of design approach and calculations in specific situations depends on what factors must be held to specific values, and what factors need only be held within an acceptable range. A simple design problem might require that only the load must be held to a specific value.

For example, assume the only design requirement is that $P = 100$ lb. As mentioned previously, only two expressions, Equations 5*a* and 7, are necessary for design purposes.

Material and working stress must be selected for evaluation of the *A* coefficients. Common design practice is to use an SAE 1095 carbon steel hardened to Rockwell C 47-50, and a working stress of 200,000 psi if the springs are not subject to severe service. Thus, from Table 4, $A_D = 314$ and $A_{tD} = 0.0396$.

The *B* coefficients are functions of D/d, h/t, and k. If there are no restrictions, good practice is to make $D/d = 1.8$ which is the most efficient proportion. When $h/t = 1.6$, the spring will give, within close limits, a constant force for a large deflection range.

For design convenience, assume that solid height is the point of maximum deflection or $\delta/h = k = 1$. From Table 5 then, $B_D = 0.079$ and $B_{tD} = 0.420$.

From Equation 5*a*,

$$D = \left[\frac{100}{314(0.079)}\right]^{1/2} \doteq 2.01 \text{ in.}$$

and from Equation 7, $t = 0.0396(0.420)(2.01) = 0.0334$ in. Since assumed value of ratio $D/d = 1.8$, $d \doteq 2.01/1.8 = 1.115$ in. Similarly, for assumed $h/t = 1.6$, $h = 1.6\ (0.0334) = 0.0535$ in., completing the design solution.

As more qualifications are imposed on a design, the more difficult it is to find a solution. For example, assume that $P = 100$ lb and $D = 3$ in. are fixed requirements. One approach to the problem might be first to assume a material and working stress, thus establishing values for the *A* coefficients. If material is again a carbon steel with $s = 200{,}000$ psi, then A_D and A_{tD} will have the same values as in the previous example. From Equation 5*a*,

$$B_D = \frac{100}{314(3)^2} = 0.0354$$

If this value can be found in Table 5, the corresponding values of k, D/t, h/t, and B_{tD} can be established and dimensions d, h, and t can be calculated. More than likely, finding the specific values of B_D and B_{tD} in the table will require interpolation. From Table 5, a combination of values which gives $B_D = 0.0354$ is $k = 1$, $D/d = 4.5$, and $h/t = 1.7$. The h/t value was obtained by interpolation.

Numerous other solutions are possible. An even greater range of possible solutions can be obtained by varying the selection of spring material and working stress.

Conical-disc springs used for energy storage are generally grouped into nests. The relatively short deflection range of a single spring limits the amount of energy that can be stored. Thus, one practical approach in the design of a nest of springs is to determine the energy capacity of a single spring of suitable dimensions, and then group as many springs in the nest as required.

Consider an application in which 50 in.-lb of energy must be stored by a nest of springs. For convenience, it will be assumed that springs with the dimensions and characteristics established in the first example are to be used ($P = 100$ lb, $D/d = 1.8$, $h/t = 1.6$ and $k = 1$).

From Table 4, $A_V = 0.00224$ for carbon steel with $s = 200{,}000$ psi. The coefficient B_V must now be evaluated. From Table 6, $U = 0.820$, and from Table 7, $1/(B_{h1})^{1/2} = 2.390$. From Table 3 then, $B_V = 0.820(2.390) = 1.960$. Finally, from Equation 8, $V = 0.00224\ (1.960)(100)^{1.5} = 4.4$ in.-lb. Number of springs N required in the nest is found by dividing the total energy required by the energy capacity of a single spring. If a fraction results, the next highest whole number is the solution. For the problem under discussion, $N = 50/4.4 = 11.4$. Thus, 12 conical-disc springs must go into the nest.

References

1. J. O. Almen and A. Laszlo—"The Uniform-Section Disk Spring," *ASME Transactions*, Vol. 58, No. 4, May, 1936, pp. 305-314.
2. G. Ashworth—"The Disk Spring or Belleville Washer," *Proceedings of the Institution of Mechanical Engineers* (England), Vol. 155, 1946, pp. 93-100.

They Say . . .

"No laboratory staff, however sophisticated and well financed, can hope to blanket all areas of a particular industry. It must pinpoint its attack in selected salients if it is to accomplish profitable breakthroughs. But, only with a clear knowledge of the desired corporate goals can it hope to mount a research effort consonant with these objectives."
—EMIL OTT, *director of research, and* CARL PRUTTON, *executive vice president, Food Machinery and Chemical Corp.*

Weldynamics

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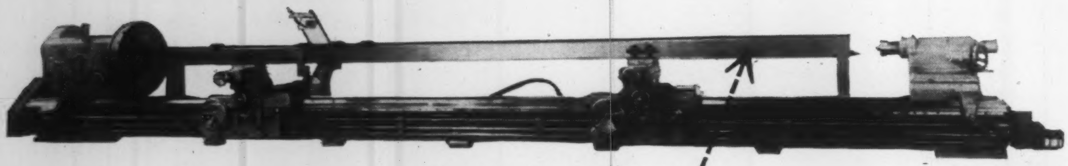
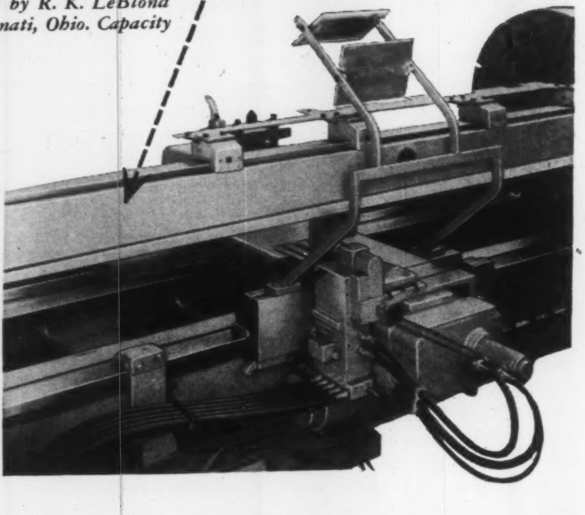


Duplicating lathe made by R. K. LeBlond Machine Tool Co., Cincinnati, Ohio. Capacity 37' between centers.



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DESIGN ABSTRACTS

mechanical

Calculating Design Stresses In Weldments

Omer Blodgett, The Lincoln Electric Co.

Presentation of a new, simplified design approach for creating efficient machine weldments. Methods presented help designers to solve problems on how to design for welding. Standard design formulas are converted into nomographs, charts, and tables for quick and accurate use.

AWS paper, "A Simplified Approach to Calculating Design Stresses," from AWS Spring Meeting, St. Louis, April, 1958; 15 *pp.*

Design Features of Hot-Extruded Steel Sections

R. L. Hugo, Jones & Laughlin Steel Corp.

A discussion of practical limitations on shapes which can be hot-extruded from alloy and carbon steels. A description of the extrusion process and its applicability are included. Illustrations show practical tolerances, radii, range of shapes, angles, and maximum dimensions which can be obtained by extrusion.

ASTE paper 62, *"Design Features and Cost Benefits of Hot-Extruded, Cold-Drawn Steel Sections," from ASTE 26th Annual Meeting, Philadelphia, May,* 1958; 9 *pp.*

Effect of Welding Speed On Strength of Aluminum Joints

William L. Burch, Bell Aircraft Corp.

Factors affecting tensile strength of welded-and-aged aluminum joints. Relationship between strength of aluminum joints after aging to welding speed or heat input is discussed. Materials include aluminum type 6061-T6. Report includes tensile and yield-strength determinations, hardness surveys, and other metallurgical considerations.

From AWS National Spring Meeting, St. Louis, April, 1958; 20 *pp.*

Lubrication Problems In High-Speed Gears

J. Dern, Steel Products Engineering Co.

A discussion of the lubrication problems involved in high-speed gear boxes. Included are design considerations for a particular gear box and an evaluation of design factors relative to performance. A discussion of the test results including the effect of short-time lubrication failure is included.

ASLE paper 58AM 6B-2, from ASLE 13th Annual Meeting, Cleveland, April, 1958; 15 *pp.*

electrical

Polyphase Motor Selection For Duty Cycle Applications

G. C. Morris, Howell Electric Motors Co.

Presentation of a method used to determine where general-purpose motors can be applied and where it is necessary to use a specially designed motor. Method is explained by means of a sample problem. Factors which help determine suitability for application are covered.

AIEE paper 58-679, from AIEE District Meeting, Lansing, Mich., May, 1958; 9 *pp.*

Selection and Application of Motors in Industry

Robert G. Marsh, Allis-Chalmers Mfg. Co.

A discussion of open and totally enclosed motor types and their suitability for various applications. Characteristics and design features of each motor type are discussed in relation to their function. Installation and alignment problems are reviewed.

AIEE paper 58-750, from AIEE District Meeting, Huntington, W. Va., May, 1958; 11 *pp.*

Power Sources For Induction Heating

C. F. Schwan and A. J. Humphrey, Reliance Electric and Engineering Co.

Description of, and application data for, power sources for induction heating. Sources include gas-discharge frequency changers, vacuum-tube oscillators, spark-gap oscillators, mercury-hydrogen gap oscillators, magnetic frequency multipliers, self-excited alternators, and inductor alternators.

AIEE paper 58-759, from AIEE District Meeting, Huntington, W. Va., May, 1958; 9 *pp.*

Synchronized Drive Systems

A. T. Bacheler, Westinghouse Electric Corp.

A comparison of the adjustable-frequency synchronous drive with the Synchrotie system. Comparisons are drawn between operating features, characteristics, and limitations of both systems, and data on available speed, starting, protective means, power supply requirements, and pullout considerations are included. It is shown how both systems are capable of operation as synchronizing links between two or more machines each driven by its own drive.

AIEE paper 58-808, "A Comparison of Adjustable Frequency AC and Synchrotie Systems for Synchronized Drives," from AIEE Summer General Meeting, Buffalo, June, 1958; 7 *pp.*

Selection of AC Motors By Torque Requirements

C. H. Buchanan, General Electric Co.

A compilation of speed-torque curves of various NEMA-design motors. Included is a discussion of design features which are responsible for the various torque characteristics. Starting methods and current requirements are included.

AIEE paper 58-724, from AIEE District Meeting, Huntington, W. Va., May 1958; 11 *pp.*

AC-Controlled Magnetic Amplifiers

E. W. Lehtonen and E. A. Cronauer, Sperry Gyroscope Co.

Description of a method for controlling full-wave amplifiers with ac signals. The methods offer the following characteristics: No current-limiting resistors, no demodulator, response similar to dc controlled amplifiers, and high gain. This form of control combines the advantages of transistors and magnetic amplifiers.

AIEE paper 58-773, from AIEE Summer General Meeting, Buffalo, June, 1958; 13 *pp.*

A New Control Amplifier

R. E. Morgan, General Electric Co.

Presentation of a method for controlling the magnetic transistor amplifier by a dc current, a variable resistor, and a small integral magnetic amplifier. Advantages of using a combination oscillator and amplifier include reliability, compactness, fast response, and economy.

AIEE paper 58-858, "A New Control Amplifier Using a Saturable Current Transformer and a Switching Transistor," from AIEE Summer General Meeting, Buffalo, June, 1958; 11 *pp.*

Electric Starting Of Aircraft Gas Turbines

C. D. Fearnot, General Electric Co.

A discussion of the way in which a designer can minimize size and weight of electric starters. Requirements of starters are discussed in terms of small engine performance. An example of how design parameters are analyzed by computers to aid designers in applying electric starters is included.

AIEE paper 58-838, from AIEE Summer General Meeting, Buffalo, June, 1958; 6 *pp.*

Advantages of a Pneumatic-Electrical Power System

M. A. Slavin, General Electric Co.

An analysis of the penalties associated with pneumatically driven electrical systems for high-speed aircraft and a comparison of these penalties with those of a shaft-driven electrical system. Comparisons are made on the basis of design factors which include weight, cooling, volume, and power extraction.

AIEE paper 58-910, "The Advantages of a Pneumatic Electrical Power System For High Mach Number Aircraft," from AIEE Summer General Meeting, Buffalo, June, 1958; 18 *pp.*

Induction Motor Temperature Characteristics

J. F. Heidbreder, Westinghouse Electric Corp.

A discussion of motor temperature limitations relative to insulation and mechanical stresses in the cage winding. Limitations are discussed and resulting limiting current-time characteristics are given for several motors. Included is a short method for predicting motor starting performance and several application aids.

AIEE paper 55-761, from AIEE Summer General Meeting, Buffalo, June, 1958; 13 *pp.*

bearings

Effect of Shaft Rotation On Bearing Temperatures

A. H. Burr, Cornell University

A method for predicting oil-film temperatures for shaft and plain-bearing combinations by a heat balance using heat-transfer data from recent studies of rotating cylinders.

ASLE paper 58AM 4A-2, from ASLE 13th Annual Meeting, Cleveland, April, 1958; 17 *pp.*

Effect of Lubricant Viscosity On Ball Fatigue Life

T. L. Carter and W. J. Anderson, NACA

Results of investigations to determine the effect of lubricants on the fatigue life of M-1 tool-steel balls. Included are the effects of viscosity and lubricant base stock on life of the balls.

ASLE paper 58AM 5A-2, from ASLE 13th Annual Meeting, Cleveland, April, 1958; 11 *pp.*

Ball Bearing Lubrication

J. B. Accinelli and S. J. Beaubien, Shell Development Co., and G. S. Reichenbach, M. I. T.

A report on friction and surface damage of contact areas of high-speed, axially loaded ball bearings at high temperatures. Included is an analysis of spinning as one of the major friction sources. Lubricants include silicone fluid, mineral oil, and a synthetic ester over a wide range of temperatures. Effects of additives used in mist-lubricated systems are covered.

ASLE paper 58AM 2C-1, "Ball Spin Friction and Lubrication of High-Speed Thrust Ball Bearings," from ASLE 13th Annual Meeting, Cleveland, April, 1958; 12 *pp.*

techniques

Four-Pole Parameters In Vibration Testing

Charles G. Malloy, Lockheed Aircraft Corp.

A discussion of the wide applicability of the four-pole technique. Preliminary definitions and fundamentals are discussed, and these are applied to problems pertinent to vibration testing. Application problems include vibration isolation, shake tables, shock machines, and vibration pickups.

IEE 2nd Annual Meeting, New York, April, 1958; 18 *pp.*

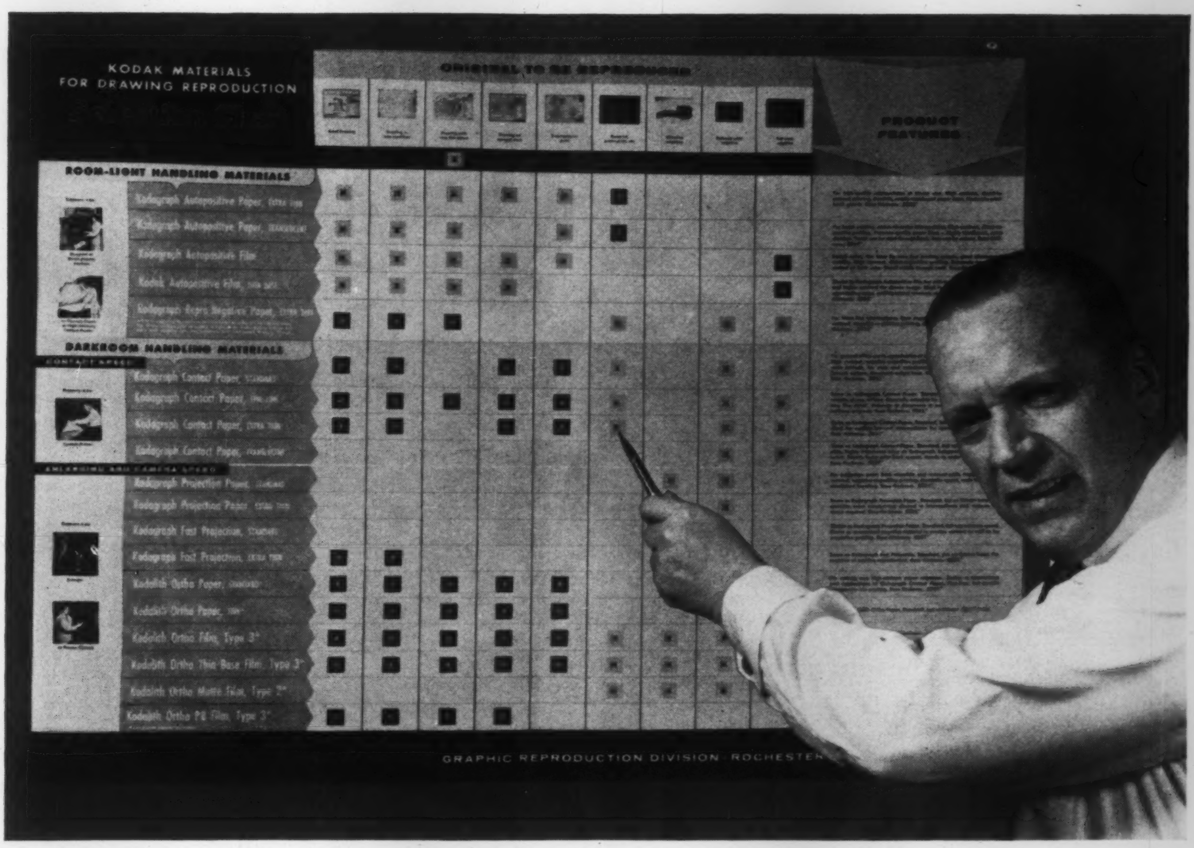
AWS—American Welding Society Inc., 33 West 39th St., New York 18, N. Y.

ASTE—American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

ASLE—American Society of Lubrication Engineers, 84 East Randolph St., Chicago 1, Ill.; papers 35 cents to members, 50 cents to nonmembers.

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

IEE—Institute of Environmental Engineers, 9 Spring St., Princeton, N. J.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Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card — page 19

Fabricated Metal Products

Illustrations of many types of metal stampings, automotive and appliance parts, and textured metals offered by this company are included in this brochure. Examples of etching, embossing, and metal decorating are shown. 12 pages. L. F. Grammes & Sons Inc., Allentown, Pa. E

Circle 601 on Page 19

Single-Phase Motors

Details on $\frac{1}{3}$ to 1-hp single-phase motors for belt driven fans and blowers are offered in illustrated Brochure SEC9-820. Types and ratings, operational characteristics, mountings, and dimensions are included. 4 pages. A. O. Smith Corp., Tipp City, Ohio. G

Circle 602 on Page 19

Electrical Insulations

The complete range of fabric, tape, varnish, and enamel insulations in the Westinghouse line is discussed from a standpoint of grade type, characteristic, and applications in Bulletin B-7206. Westinghouse Electric Corp., Benolite plant, Manor, Pa. F

Circle 603 on Page 19

Fluorocarbon Plastic

Electrical, physical, mechanical, and chemical properties of Rulon, a "super-Teflon" fluorocarbon, are compared with Teflon on data sheet. Proven applications of the inert material are given. 2 pages. Dixon Corp., Plastics Div., Bristol, R. I. B

Circle 604 on Page 19

Small Drives

Shown in illustrated bulletin are low-cost differentials for up to 6-hp drives and combination variable speed pulley and clutch for these same loads. 4 pages. Cizek Mfg. & Distributing Co., Clutier, Iowa. I

Circle 605 on Page 19

Air Motor

Quick starts and stops, nonsparking characteristics, and no burnouts on stalling are features of the 71A-1 Series air motor described in Bulletin 71-21. Motors are suitable for either continuous or intermittent duty. Gardner-Denver Co., 1350 Front St., Quincy, Ill. I

Circle 606 on Page 19

Electrical Products

Describing a complete line of electrical products, Catalog C 758 covers pres-SURE-connectors for solderless splices and terminations, pres-SURE-blocks, one-piece terminal blocks, 4-way crimped terminals, Romex connectors, conduit bushings, Knock-out plugs, and cable staples. 12 pages. Buchanan Electrical Products Corp., Hillside, N. J. D

Circle 607 on Page 19

Two-Pin Lampholder

The No. H2005-IL Minispace lampholder which allows the use of two-pin lamps in applications involving high ambient tempertaures, has a glass fiber base. Data sheet gives complete dimensional information. Drake Mfg. Co., 1711 W. Hubbard St., Chicago 22, Ill. I

Circle 608 on Page 19

Tool Components

Over 300 tool, jig, and fixture components are listed and shown in Catalog 16. This condensed data book covers such items as clamps, studs, thumbscrews, swing washers, studs, screws, and round shafting. 32 pages. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 609 on Page 19

Selenium Rectifiers

Descriptive data and specifications for Syntron vacuum process rectifier plates and stacks, and for cartridge-type rectifiers and stacks are furnished in Bulletin 45656-2. Twenty sizes range from 1 x 1 in. to 12 x 16 in. 8 pages. Syntron Co., Homer City, Pa. F

Circle 610 on Page 19

Casters

Catalog 157-G lists casters for industry and other uses. These include light, light-medium, medium, medium-heavy, heavy, and extra-heavy duty casters; spring-action and V-grooved wheel casters; grease-sealed units; scaffold casters and floor truck locks; caster wheels; and furniture casters, sockets, and glides. 20 pages. Faultless Caster Corp., Evansville, Ind. J

Circle 611 on Page 19

Rotary & Swing Joints

Bulletin BMP 101 deals with design details and applications of ball joints for angular and swivel motion, revolving joints for continuous rotation, swivel joints for self-aligning swivel motion, and swing joints for swing motion. Sizes and pressure and temperature ratings are available for practically every piping or equipment need. 4 pages. Barco Mfg. Co., 500 Hough Ave., Barrington, Ill. J

Circle 612 on Page 19

Lighting Ideas

Sixty ideas for incorporating lighting into a variety of products ranging from household appliances, through vending machines to commercial displays and signs are contained in "A Sketchbook for Product Designers." Text points up added sales appeal, beauty, and utility factors. 22 pages. General Electric Co., Nela Park, Cleveland 12, Ohio. F

Circle 613 on Page 19

High-Voltage Terminals

Booklet covering application of alumina ceramic-to-metal terminals describes an improved sealing technique used in high-voltage terminal manufacture. Engineering data and dimensional drawings are provided. 8 pages. Advanced Vacuum Products, Inc., Keasbey, N. J. D

Circle 614 on Page 19

Check Valves

Over 40 illustrations accompany descriptions of bronze and iron body check valves in Brochure V-63. Valves prevent return or back flow through pipe lines and are used on hot or cold water, oil, and gasoline lines. 4 pages. Fairbanks Co., 393 Lafayette St., New York 3, N. Y. D

Circle 615 on Page 19

Cold Finished Bars

Revised Buyers' Guide 12-5 to cold finished carbon steel bars lists 23 different types. Mechanical properties, formability, weldability, heat treatment response, machinability, relative cost, shapes, and sizes are covered. 4 pages. Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill. I

Circle 616 on Page 19

Metals Chart

One side of this metals chart shows melting points of metals in both Fahrenheit and centrigrade scales, whereas other side shows densities of metals, grouped into heavy, medium, and light classifications. Fansteel Metallurgical Corp., Metals and Fabrication Div., North Chicago, Ill. J

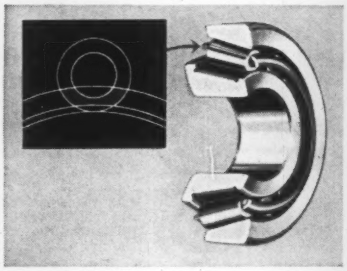
Circle 617 on Page 19

Thermocouple Tables

Millivolts-to-degrees and degrees-to-millivolts reference tables based upon the 150° F reference temperature comprise this two-way bulletin. Tables facilitate the use of company's heater type Thermocouple Reference Junction. 10 pages. Pace Engineering Co., 6914 Beck Ave., North Hollywood, Calif. L

Circle 618 on Page 19

Tomorrow's "dream" is our job today!



HIGHER FLANGE IMPROVES ROLLER ALIGNMENT

As shown by the gray area above, the higher flange provides a large two-zone contact area for the roller heads. This greatly reduces wear—practically eliminates "end play". Larger oil groove provides positive lubrication.

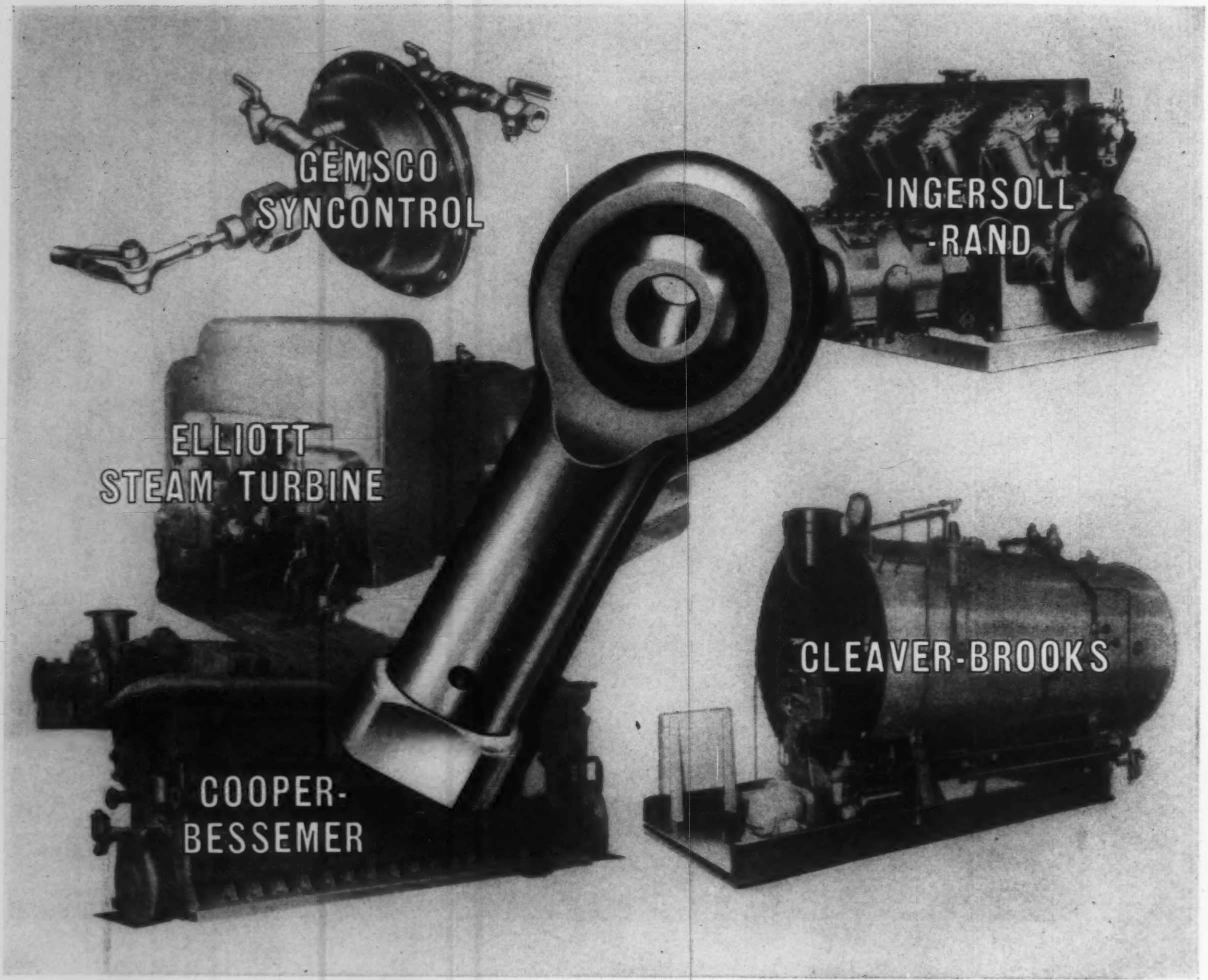
There's more to the car of tomorrow than just futuristic styling! Automotive engineers are working to perfect completely new power plants—like turbine engines—to achieve yet-unheard-of performance and economy! And they demand bearings that are as advanced as their thinking. This is no new challenge to Bower engineers. A glance at the design features listed at left will tell you a few of the many original Bower contributions to bearing performance which have reduced bearing maintenance and failure to a practical minimum. There are many more in the making. If your product is one which needs advanced bearings *today* plus realistic planning for the future, specify Bower. There's a complete line of tapered, straight and journal roller bearings for every field of transportation and industry.

BOWER ROLLER BEARING DIVISION
FEDERAL-MOGUL-BOWER BEARINGS, INC. • DETROIT 14, MICHIGAN

SPHER HONED

BOWER ROLLER BEARINGS

Circle 480 on Page 19



Engine, Boiler, Turbine, and Control Manufacturers specify . . .

HEIM *Unibal*®

SPHERICAL BEARING ROD ENDS

For changing lateral motion or power to vertical or transverse motion, many rod assembly designs are used. Some of the factors which influence the design of a push-pull rod assembly are:

Load — compression, tension, or vibration.

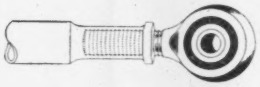
Length — as it affects column strength.

Space allotted — envelope dimensions.

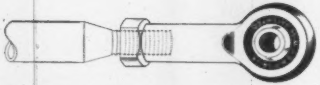
End fittings — method of attachment to adjacent operating units.

The majority of rods used in linkages have male threaded ends to which an adjustable rod end bearing is attached. The rods may also be female threaded with a Heim Unibal male rod end bearing. This type of assembly presents some advantages in that the smallest diameter of the Unibal may be closer to the point of attachment.

See illustration of both methods.



Female threaded rod with adjustable male unibal rod end bearing



Male threaded rod with adjustable female unibal rod end bearing

Because of the universal motion of the single ball, the Heim Unibal Bearing has the ability to correct shaft or linkage misalignment in all directions.

Assembly is quick and simple. Greater load ratings for substantially smaller dimensions are attained.

Many leading manufacturers of equipment requiring push-pull linkages depend on Heim Unibal.

Call or write now for engineering advice and complete catalog. Also list of distributors and representatives.

THE HEIM COMPANY FAIRFIELD, CONN.

For Prompt Service, contact any one of our more than 150 distributing points across the country.

Miniature Switches

Engineering Catalog G-300 covers the Grayhill line of miniature pushbotton switches, rotary switches, binding posts, test clips, and other components as to dimenisons and specifications. Eleven new products incorporated in catalog represent latest advances in miniaturization. 24 pages. Grayhill, Inc., 561 Hillgrove Ave., La Grange, Ill. I

Circle 619 on Page 19

Hydraulic Pumps & Motors

Outlining a complete line of hydraulic pumps, motors, and controls, Bulletin 146-E gives specification data sheet numbers for designers requiring detailed information on specific units. Service ratings range up to 5000 psi. 4 pages. American Brake Shoe Co., Denison Engineering Div., 1160 Dublin Rd., Columbus 16, Ohio. G

Circle 620 on Page 19

Time Delay Timers

Bulletin 300 is descriptive of line of synchronous motor driven, automatic reset, time delay timers with various time cycles in the range of 1 second to 3 hours. All are adjustable within their timing ranges. Contact ratings are 10 amp on 115/230 v ac. 4 pages. Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J. D

Circle 621 on Page 19

Solenoid Valves

Specifications, construction data, service ratings, and dimensions are presented in Bulletin 700-Q on normally closed and normally open solenoid valves in 3/8 to 3 in. NPT sizes. Valves are rated to 400 psi for air, gas, steam, and light oil service. 2 pages. J. D. Gould Co., 4707 Massachusetts Ave., Indianapolis 18, Ind. J

Circle 622 on Page 19

Miniature Lampholders

Dimensional and mounting information on two-pin miniature lampholders is given in data sheet. Thirteen combinations of brackets for varying needs are shown. Advantages of the two-pin lamp are cited as fast assembly and replacement, vibration resistance, and shockproof design. 1 page. Drake Mfg. Co., 1711 W. Hubbard St., Chicago 22, Ill. I

Circle 623 on Page 19

Packaged Drives

Complete engineering and application data on the Ultraflex line of adjustable speed direct-current packaged drives are given in Bulletins EN-64 and EN-65. First described is the Ultraflex E, a 1 to 40-hp drive which uses electronic tubes for power conversion. Second booklet details the Ultraflex M drive in sizes from 1 to 200 hp which uses magnetic amplifiers for power conversion. 12 pages each. Cutler-Hammer, Inc., 328 N. Twelfth St., Milwaukee 1, Wis. K

Circle 624 on Page 19

THE STRAIGHT PATH
TO SUCCESSFUL DESIGNING
WOOD
PLASTIC
URANIUM
METAL
MODERN
Gray Iron
CASTINGS

• In the light of recent developments, the straight path to successful designing is modern gray iron castings. Here's why:
FIRST, the directness of the casting process saves valuable engineering time in designing.
SECOND, gray iron's range of properties has been greatly improved—ductile irons are now available.
THIRD, in automatic processes it is much easier to process a single casting than units made out of component parts.
For these reasons, plus the traditional ease of production of castings direct from molten metal to finished product, make modern gray iron castings your first consideration.

NEW
620 Page Handbook

To help you design successfully and economically, the Gray Iron Founders' Society has compiled this 620-page handbook. Just off the press, this valuable reference has hundreds of suggestions on how to improve products and cut manufacturing costs. Covers 263 subjects on properly designing, purchasing and applying gray and ductile iron castings.

GRAY IRON FOUNDERS' SOCIETY INC.
National City-East Sixth Building
Cleveland 14, Ohio

Please send your 620-page handbook for TEN DAYS FREE EXAMINATION. At the end of the examination period I will remit $10 or return book.

☐ $10 enclosed ☐ Bill after 10 days
☐ Purchase Order enclosed

Name__________

Company__________

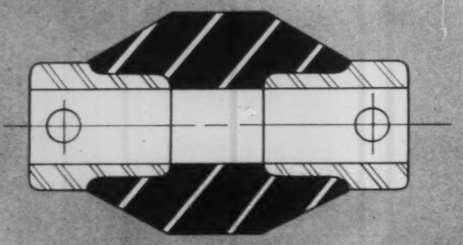
Address__________

City__________ Zone_____ State_____

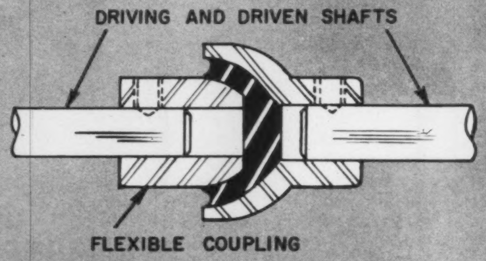
TIME TO DESIGN WITH ***MODERN GRAY IRON CASTINGS!***

Circle 482 on Page 19

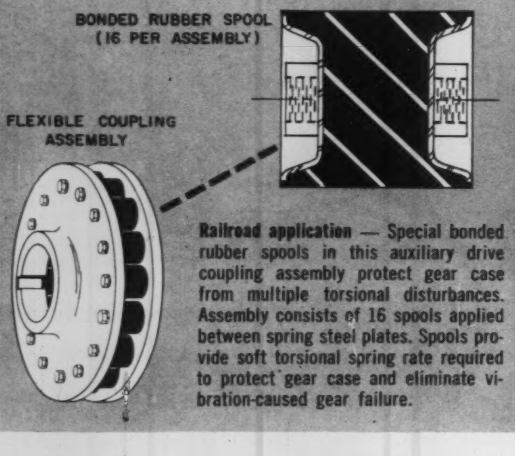
custom-designed LORD flexible couplings provide improved equipment performance



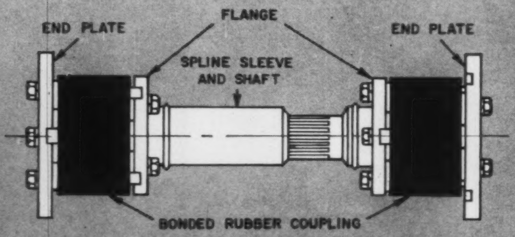
Business machine application — This coupling is uniquely applied in series of four pieces in gear train of business machine. Bonded rubber construction virtually eliminates noise transmission and accommodates shaft misalignment, assuring fast, accurate operation. Special elastomer contour imparts exact degree of torsional stiffness required.



Home appliance application — Special close-tolerance coupling transmits high motor torque in rugged washer-dryer application. Custom-compounded elastomer withstands high operating temperatures. Coupling accommodates 2° shaft misalignment, reduces noise and bearing wear.


BONDED RUBBER SPOOL (16 PER ASSEMBLY)
FLEXIBLE COUPLING ASSEMBLY

Railroad application — Special bonded rubber spools in this auxiliary drive coupling assembly protect gear case from multiple torsional disturbances. Assembly consists of 16 spools applied between spring steel plates. Spools provide soft torsional spring rate required to protect gear case and eliminate vibration-caused gear failure.



Marine application — Custom-designed, non-magnetic coupling assembly, used on minesweeper main propulsion shaft, attenuates noise and accommodates shaft misalignment. Rated at 15,400 in.-lb. torque, it accommodates continuous misalignment of ¾″ and momentary misalignment of 1¼″ in all directions. Coupling is typical of high horsepower applications featuring optional fail-safe protection.

You will get optimum product performance with special Lord Flexible Couplings regardless of the specific requirements of your application.

Here are the performance benefits you can obtain. Efficient isolation of torsional vibration and shock. Accommodation of all misalignment—angular, parallel and axial. Smooth, quiet, constant speed transmission of power with no backlash. No lubrication or maintenance. Extreme overload protection. Long service life despite tough operating conditions. Torque capacities from inch-ounces to foot-tons.

Bring your flexible coupling problems to Lord where you will find complete research, test and production facilities. Here, 20 years of engineering experience in flexible coupling design can produce an accurate solution for your application.

Contact your nearest Lord Field Engineer or the Home Office, Erie, Pennsylvania.

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA - CEdar 7-9247
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DETROIT, MICH. - DIamond 1-4340
KANSAS CITY, MO. - WEstport 1-0138
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"In Canada — Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD
BONDED RUBBER

Circle 483 on Page 19

Space-Saving Motors

Uses and characteristics of the Peerless line of Spacesaver motors in ratings from ½ to 10 hp are presented in Bulletin SP-1. Units are reportedly as much as 50 per cent smaller than conventional motors with the same horsepower ratings. Peerless Electric Co., Motor Div., Warren, Ohio. G

Circle 625 on Page 19

Thermistors

Fifteen different thermistor circuits and almost 400 thermistors are described in illustrated Catalog EMC-2. Thermistor assemblies, matched pairs, beads, discs, washers, rods, and probes are covered. Basic properties and characteristics are given. 16 pages. Fenwal Electronics, Inc., Mellen St., Framingham, Mass. B

Circle 626 on Page 19

Evaluating Print Paper

"Checklist of Important Factors in Evaluating Print Quality" aims to compare print quality impartially, to aid training of reproduction personnel, and to suggest practical testing techniques involving diazo-type prints. Frederick Post Co., Box 803, Chicago 90, Ill. J

Circle 627 on Page 19

Variable Displacement Pump

An integral, infinitely adjustable pressure unloading control with a range of 200-1100 psi and adjustable volumes up to 3100 cu in. per minute are features of the Power Saver variable displacement pump, subject of illustrated Bulletin 47550. Features, operational data, and specifications are included. 4 pages. Oilgear Co., 1570Q W. Pierce St., Milwaukee 4, Wis. K

Circle 628 on Page 19

Electrical Connector

AMP-lok connector can be used as a through-panel, or free-hanging multiple connector. Its features and specifications are pointed up in Form 410. 2 pages. AMP Inc., Harrisburg, Pa. E

Circle 629 on Page 19

Indicating Flowmeters

Ranges, scales, pressures, and mechanical details of a line of Seico indicating flowmeters for use with air, gas, and liquids are furnished in Bulletin V-100. It also explains the movable vane principle of these flowmeters and the three systems of indication. 4 pages. Eclipse Fuel Engineering Co., Seico Instrument Div., Rockford, Ill. K

Circle 630 on Page 19

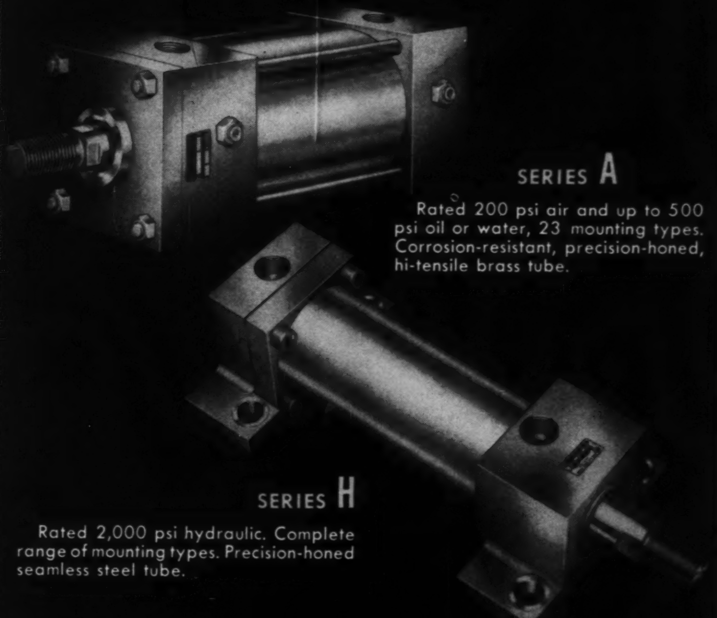
Printed Circuits, Laminates

Norplex printed circuits, copper-clad laminates, base laminates, and fabricated parts are discussed in folder. It provides NEMA values, design recommendations, and tolerances. 4 pages. Northern Plastics Corp., LaCrosse, Wis. K

Circle 631 on Page 19

for increased production . . .
minimum down-time . . .
lower costs . . . specify SP

AIR and HYDRAULIC CYLINDERS



SERIES A

Rated 200 psi air and up to 500 psi oil or water, 23 mounting types. Corrosion-resistant, precision-honed, hi-tensile brass tube.

SERIES H

Rated 2,000 psi hydraulic. Complete range of mounting types. Precision-honed seamless steel tube.

- floating cushions—uniform cushioning—long life—fully adjustable
- easily removed cartridge-type rod seals with integral rod wiper
- choice of rod sizes for all applications—rods heat-treated and hard chrome plated for resistance to nicking and scoring
- steel heads and end plates for strength and positive alignment
- all ferrous parts rust-proofed

Before you buy any cylinder, consider the quality design and construction features of S-P air and hydraulic cylinders—features that will assure dependable performance . . . long service life . . . minimum down-time . . . lowest end cost.

What's your cylinder problem? We'd like to help you solve it—a phone call will bring our representative on the double. Prompt deliveries, too. The S-P Manufacturing Corporation, 30201 Aurora Road, Solon, Ohio.

SP for speed and performance

Representatives in principal cities.
Phone or write for Catalogs
No. 110B (Series A)
and No. 104A (Series H).

Find us fast in the 'Yellow Pages'

NON-ROTATING AIR AND HYDRAULIC CYLINDERS • ROTATING AIR AND HYDRAULIC CYLINDERS • POWER CHUCKS • COLLET AND DRILL PRESS CHUCKS • VALVES, ACCESSORIES

A BASSETT COMPANY • IN GREATER CLEVELAND • ESTABLISHED 1916

AA-7487

Circle 484 on Page 19

ACME

GETS THE CHAIN TO YOU WHEN YOU NEED IT

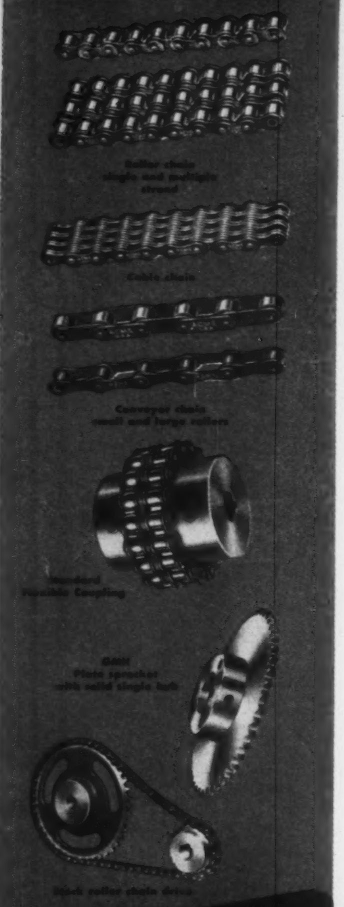
No costly delays when you specify ACME

With Acme you can be sure there won't be any costly delays or production line shut-downs because of non-availability of replacement parts. We back our Industrial Distributors with complete stocks of all standard Roller Chains, Double Pitch Chains and Sprockets ready for immediate shipment in case of emergency.

On Time Delivery is but one of many Acme Services that assures customers of maximum production efficiency and economy. Call on us at any time for Engineering Service and advice.

prompt delivery in all sizes on ACME chains, sprockets, couplings

in any quantity from your Distributor


Roller chain single and multiple strand
Cable chain
Conveyor chain small and large rollers
Standard Flexible Coupling
Plate sprocket with solid single hub
Stock roller chain drive

Write Dept. 6-S for new illustrated 100 page catalog which includes new engineering section showing 36 methods of chain driving.

Call ACME for Service

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

Circle 485 on Page 19

Precision Metal Strip

Designed to aid the electronics or design engineer in selecting the right precision-rolled metal strip for miniaturization, nuclear, electrical, aircraft, or instrumentation use, illustrated pamphlet is entitled "Electronics Precision Strip Selector." Practically all metals are available in thicknesses down to 0.005 in. American Silver Co., 36-07 Prince St., Flushing 54, N. Y. D

Circle 632 on Page 19

Chemical Pumps

High pressure, zero leakage, canned pumps in capacities to 350 gpm and heads to 250 ft are described and illustrated in Bulletin 1070. Line pressures to 3000 psi and higher are handled by the sealless centrifugal motor pumps. 4 pages. Chempump Corp., 1300 E. Mermaid Lane, Philadelphia 18, Pa. E

Circle 633 on Page 19

Helical Gear Drives

Folder 2651A, a supplement to Book 2651, provides horsepower ratings, dimensions, mounting information, and a resume of construction principles relative to a new quadruple reduction gear drive. Similar data on new double and triple reduction helical gear drives are given. Capacities range up to more than 200 hp. 6 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill. J

Circle 634 on Page 19

Capacitor-Start Motors

Design and engineering features of Baltric line of Streamcooled TEFC capacitor-start motors are given in Bulletin 700. Speed, frame type, NEMA number, and prices are given for 1/4 to 2-hp models on price sheet. 3 pages. Baldor Electric Co., 4353 Ducan Ave., St. Louis 10, Mo. I

Circle 635 on Page 19

Float Valves

Auxiliary-actuated Type 214 and 216 float valves which permit control of liquid levels within 1-in. limits in open or closed vessels are subject of illustrated Catalog Sheet V. Inlet pressure range is 15 to 150 psi. 2 pages. Atlas Valve Co., 280 South St., Newark 5, N. J. D

Circle 636 on Page 19

Stainless Hose Clamps

Hose clamps made of stainless steel and adaptable for automotive, aircraft, and industrial uses are described in series of bulletins. Also covered are plated steel types. 12 pages. Wittek Mfg. Co., 4305-37 W. 24th Place, Chicago 23, Ill. J

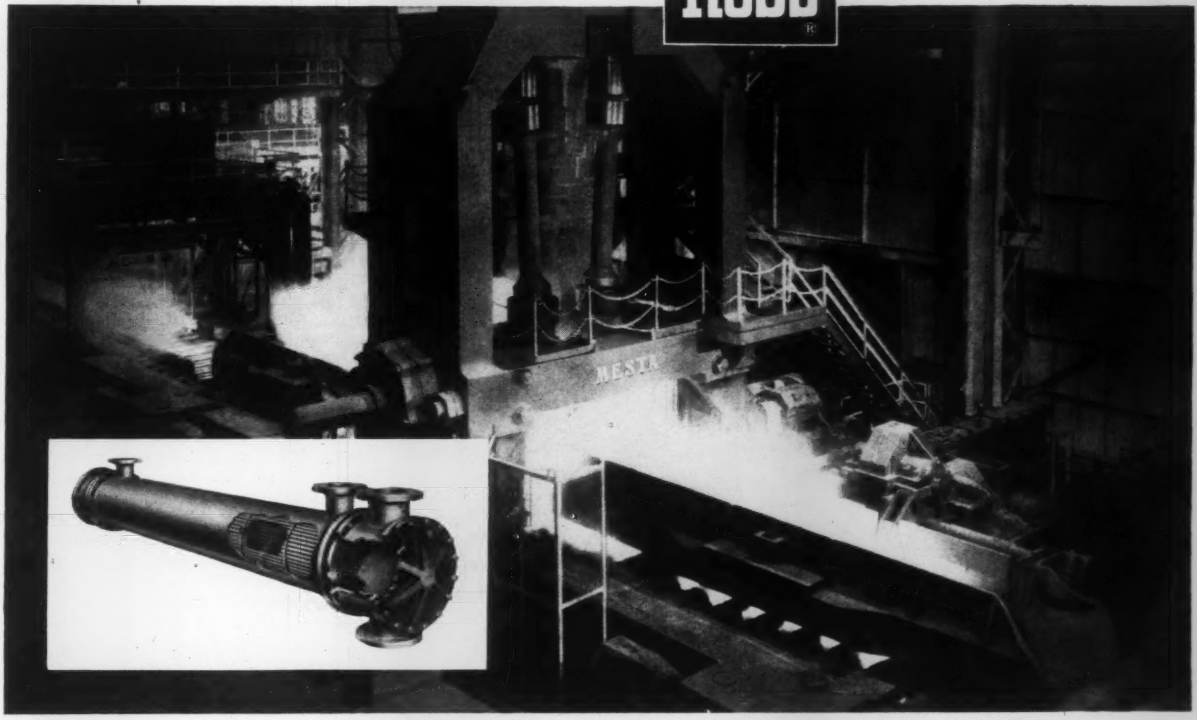
Circle 637 on Page 19

Regulating Valves

Flowrite single-seal valves for control and regulation of fluids at pressures to 125 psi are available in 1/2 to 6-in. sizes. Capacity and design details are given in Bulletin 344-S. 4 pages. Power Regulator Co., Skokie, Ill. I

Circle 638 on Page 19

OIL COOLING BY ROSS



Blazing ingots thinned to glowing slabs
in this Mesta Mill

HEAVY SHOCK LOADS, scorching heat and continuous operation — they're all part of the job as this Mesta Universal Reversing Slabbing Mill rolls red hot steel ingots into slabs.

UNDER THESE SEVERE conditions where working temperatures of gears and bearings will often exceed 200°F., temperature-safe lubrication is a prime requirement. Even a lubrication failure at a minor point could shut down the entire mill.

THAT'S WHY Mesta selected two Ross Type CP Exchangers to provide dependable cooling of the circulating oil. Roll neck bearings, main drive gears and all hard working parts are given continuous protection by oil at the right temperature and right viscosity.

THROUGHOUT the metal industry, Ross Exchangers are counted on to safeguard the performance of engines, compressors, extrusion presses, metal drawing presses, welders, die casting machines, speed changers and other prime equipment. They're top-rated for thermal efficiency and ruggedness.

COMPACT IN DESIGN, easy to install and easy to maintain, Ross Exchangers are pre-engineered and fully standardized in a wide range of sizes to meet your heat transfer requirements.

For detailed information, send coupon below requesting Bulletin 2.1K5.

*AMERICAN-Standard and Standard ® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
ROSS HEAT EXCHANGER DIVISION

TO:

American-Standard MD 9
Ross Heat Exchanger Division
Buffalo 5, N. Y.

Please send, without obligation, your Bulletin 2.1K5 describing Ross Type CP Exchangers.

NAME

TITLE

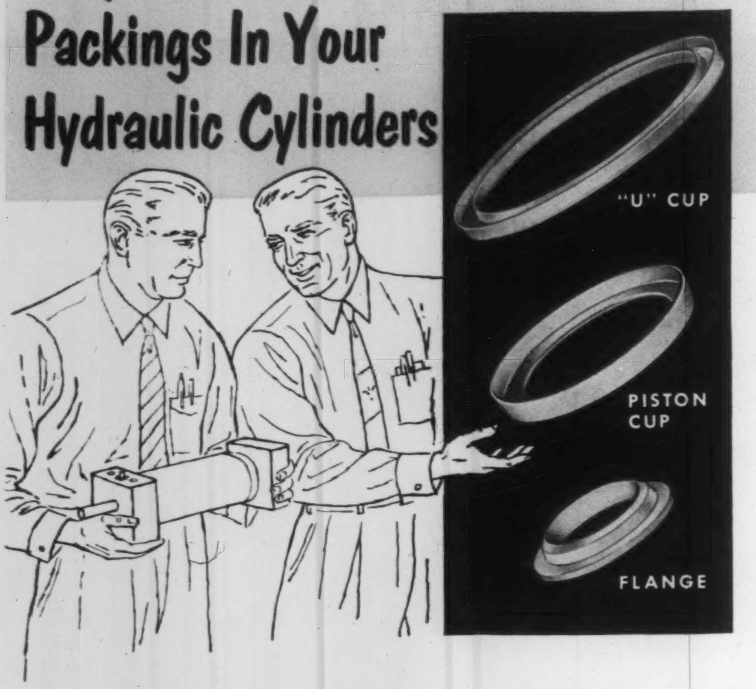
COMPANY

ADDRESS

CITY ZONE STATE

Circle 486 on Page 19

Why Use Less Than Chemlon* Packings In Your Hydraulic Cylinders



Hydraulic equipment manufacturers are now taking a *second* look at the many advantages of "John Crane" CHEMLON hydraulic packings and offering them in place of leather, fabric-reinforced and similar packings.

THE REASON . . . CHEMLON provides several very important service advantages.

1. Increased cylinder life due to the inherent non-frictional qualities of CHEMLON.
2. Longer packing service life—CHEMLON outlasts all other types of packing to a remarkable degree . . . decidedly cuts replacement, down time and maintenance.
3. Universal application—CHEMLON'S inertness to all types of hydraulic fluids, including non-flammables and synthetics . . . eliminates the need for customers stocking a wide range of special packings.
4. Trouble-free performance—CHEMLON withstands temperature conditions encountered in hydraulic service up to 350°F.

"John Crane" CHEMLON—*The Best in Teflon*—offers a complete line of piston cup, "U" cup and flange packing for every service requirement.

Get the new bulletin No. P-322 on "John Crane" Hydraulic Packings.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

PISTON CUP
"U" CUP AND
FLANGE PACKINGS

*"John Crane" fabricated from DuPont Teflon

John Crane
MECHANICAL PACKINGS · SHAFT SEALS · TEFLON PRODUCTS · LAPPING MACHINES · THREAD COMPOUNDS

CRANE PACKING COMPANY

Circle 487 on Page 19

HELPFUL LITERATURE

Precision Potentiometers

Included in Data Sheet 1273 are dimensional drawings, table of coil characteristics for resistance values from 350 to 450,000 ohms, and other information on Series 7600 10-turn precision potentiometers. 4 pages. Beckman/Helipot Corp., Newport Beach, Calif. L

Circle 639 on Page 19

Phenolic Products

Reproduced from Sweet's "Product Design File," Catalog CDC-344 gives design information on a complete line of phenolic resins, varnishes, and molding powders. Included are technical data, properties, and features of these materials. 12 pages. General Electric Co., Chemical Materials Dept., 1 Plastics Ave., Pittsfield, Mass. B

Circle 640 on Page 19

Rotary Power Units

Controlled by an external mechanical signal, Series 6000 pneumatic power units provide up to 210 lb-in. maximum torque at 10,000 rpm with 300-psi air. Units are available in ratings from 0.66 to 30 hp. They are detailed in Product Data Sheet 114-1A. 2 pages. Lear Grand Rapids Div., 110 Ionia Ave. N. W., Grand Rapids 2, Mich. H

Circle 641 on Page 19

Clutch

Exactuators are high speed clutches which engage in less than 1 millisecond. Details of these electro-mechanical units are given in Bulletin C-1. They operate on up to 13 v dc and provide up to 32 oz-in. torque. 1 page. Norman Hardy Associates, Box 97, Wyncote, Pa. E

Circle 642 on Page 19

Speed-Changing Drive

Usable on drill presses and other machines requiring up to $\frac{3}{4}$ hp, Insta-Matic drive permits speeds to be changed while machine is running. Full details are given in illustrated bulletin. 2 pages. Alda Plastics & Mfg. Co., 2601 Norton Ave., Lynwood, Calif. M

Circle 643 on Page 19

Propellant Actuated Units

Guillotine type cutters, destructors, electrical disconnects, frangible fasteners, igniters, and valves are among the products which use propellant cells for their initiating power. Typical circuits are shown in descriptive Bulletin PAD-358. 4 pages. Beckman & Whitley, Inc., 973 E. San Carlos Ave., San Carlos, Calif. M

Circle 644 on Page 19

Aircraft-Missile Switches

"Custom Designed Switches for Aircraft and Missile Applications" is title of brochure which covers ten representative switches designed expressly for these services. Results of environmental tests are listed. 6 pages. Airtron, Inc., 1096 W. Elizabeth Ave., Linden, N. J. D

Circle 645 on Page 19

Static Eliminator

"Static Can Be Fun" is title of illustrated folder which lets you perform some static experiments with a sheet of Mylar film. It goes on to point out that static can slow down production and that by use of Simco static eliminators (described and illustrated) the trouble can be stopped. Various applications are shown. 4 pages. Simco Co., 920 Walnut St., Lansdale, Pa. E

Circle 646 on Page 19

Hydraulic Pumps

Capacities up to 25 gpm are offered in line of hydraulic pumps with interchangeable pump cartridges. Described in illustrated Bulletin 209-160, they are offered with speeds up to 60,000 rpm and pressures to 4000 psi. Design features, characteristics, and operational details are given. 4 pages. General Metals Corp., Adel Precision Products Div., 10777 Vanowen St., Burbank, Calif. L

Circle 647 on Page 19

Stainless Tubing

How the use of the correct type of stainless steel mechanical tubing will result in savings to the manufacturer is related in Technical Bulletin TB-365A. Tolerance tables cover diameter, ovality, wall thickness, straightness, length, and machining allowances for seamless and welded tubing. 8 pages. Babcock & Wilcox Co., Beaver Falls, Pa. C

Circle 648 on Page 19

Production Facilities

Manufacturing capabilities of company in regard to such factors as humidity, shock, sand, dust, salt spray, acceleration, altitude, temperature, and vibration in their transducers, inertia switches, accelerometers, pitch-yaw indicators, and pendulums are cited in "Facilities" bulletin. Edcliff Instruments, 1711 S. Mountain Ave., Monrovia, Calif. L

Circle 649 on Page 19

Adjustable Speed Drives

Packaged direct current adjustable speed drives from 3 to 150 hp are described and illustrated in Bulletin GEA-6643. Units are rated 220, 440, 550 v, three-phase, 60 cycles. Bulletin includes a power unit data slide rule for calculating case dimensions, horsepower, speed, motor frame size, etc. 16 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 650 on Page 19

Research & Production

The story of company's personnel; research, production, and development facilities; and product activities is related in Bulletin 8-1-258. Laboratory facilities include those in the fields of electronics, equipment production, transformers, and nuclear devices. 8 pages. Levinthal Electronic Products, Inc., Stanford Industrial Park, Palo Alto, Calif. L

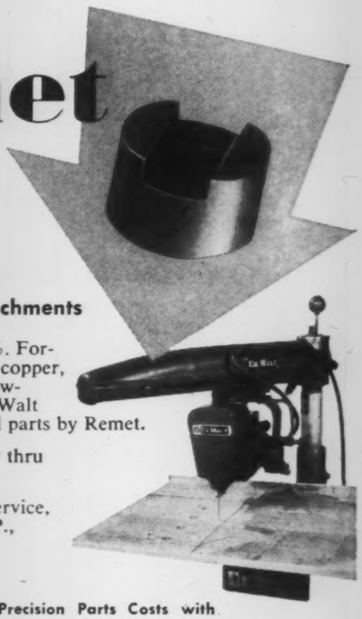
Circle 651 on Page 19

11 Remet

POWDERED METAL PARTS

now go into
DeWalt POWER SAW
and attachments

- This Remet collar reduced part cost 80%. Formerly a precision casting in beryllium copper, it is now a Remet copper infiltrated powdered iron part. Advantages led to DeWalt specifying 11 different powdered metal parts by Remet.
- DeWalt now offers greater saw accuracy thru maintenance of closer tolerances.
- "You can depend on Remet for better service, fast delivery," states A. C. Wedge, V.P., Mfg., DeWalt Div., American Machine & Foundry Company.



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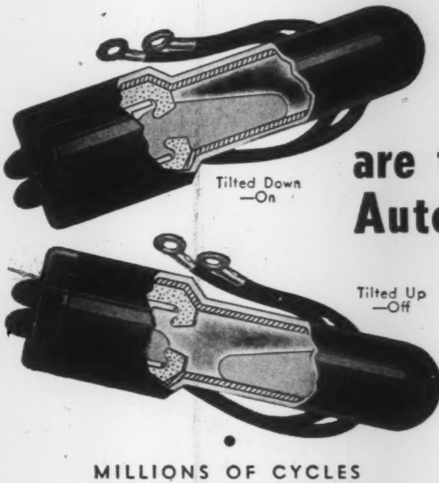
Circle 488 on Page 19



DURAKOOL Tilt Switches are the Life of your Automatic Controls

This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin D-49.

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Durakool ALL-STEEL MERCURY *Switches*

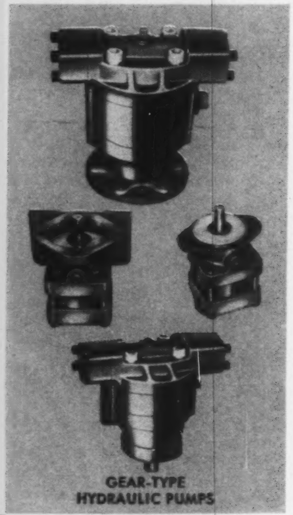
Circle 489 on Page 19

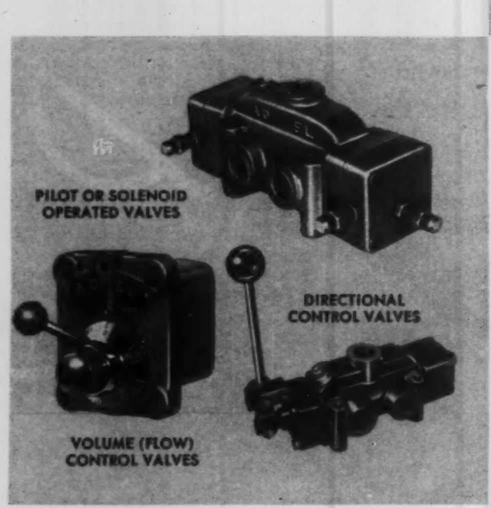
ADEL Automates

your manual machines *with*

Industrial Hydraulic Components

Modernize and automate your existing machines with ADEL Hydraulic Pumps, Motors and Control Valves.
Machine builders for the industrial, construction and agricultural fields specify ADEL components as standard equipment.





ADEL Hydraulics' experience in the design, development and precision production of hydraulic equipment has produced components of unusual reliability, efficiency and economy. These proven Pumps, Motors and Control Valves, available in a wide variety of types, sizes and mountings, may mean new economies in your hydraulic system costs.

Complete engineering specifications are available upon request.

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A DIVISION OF GENERAL METALS CORPORATION

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Milwaukee 17

Circle 490 on Page 19

Investment Casting

Investment casting is described, and when and why it should be used in preference to other casting methods is related in Catalog 201. Company investment casting facilities are described. 2 pages. Alloy Steel Casting Co., 107 County Line Rd., Southampton, Pa. E

Circle 652 on Page 19

Drafting Templates

Line of symbol, circle, ellipse, alphabet, and other templates used by engineers, draftsmen, and others is illustrated in Catalog 58. Twenty-eight different templates and sets are described and their prices given. All are made of 0.020-in. plastic. 8 pages. Timely Products Co., Box 416, Basil, Ohio. G

Circle 653 on Page 19

Silicon Rectifiers

Basic types of selenium, copper oxide, and silicon rectifiers are illustrated and briefly described in folder. Dimensional data, electrical characteristics, temperature ranges, and types of packaging and finishes available are given. 4 pages. Bradley Laboratories, Inc., New Haven 11, Conn. B

Circle 654 on Page 19

Rotary Torque Actuators

Design, construction features, specifications, and application data for Rotac rotary oscillating torque actuators are found in illustrated Catalog 26282. Motion is limited to maximum arc of 280 degrees. Use of two vanes doubles power. 20 pages. Ex-Cell-O Corp., 1200 Oakman Blvd., Detroit 32, Mich. H

Circle 655 on Page 19

Casters & Wheels

Specifications, features, suggested uses, mounting dimensions, and capacity ratings for each series of industrial casters and wheels are presented in illustrated Catalog 59. Section is also devoted to custom-built casters. 44 pages. Albion Industries, Inc., Albion, Mich. H

Circle 656 on Page 19

Composition Contacts

Composition electrical contacts produced from metal powder combinations are described in Manual 12-A on selection and use. Materials are combined to take advantage of each material or to obtain properties not present in separate materials. Factors influencing selection are covered, along with properties. 54 pages. Request on company letterhead from Stackpole Carbon Co., St. Marys, Pa. N

2-D & 3-D Cams

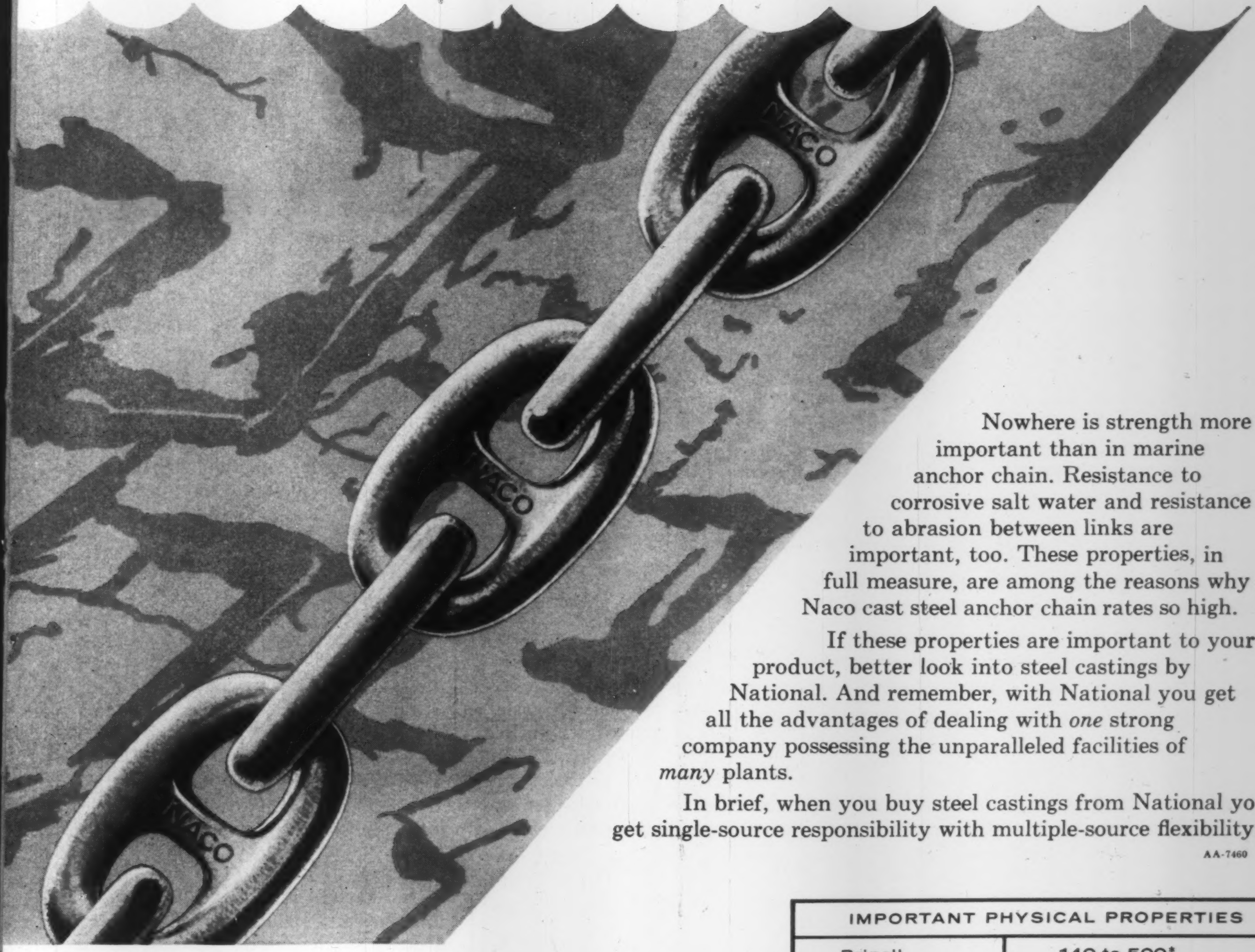
Design and functions of two and three-dimensional cams, their uses, and formulas are detailed in illustrated booklet. Why 3-D cams are used and their mechanics and engineering are covered. Examples of special 3-D cams are shown. 12 pages. Request on company letterhead from Parker-Hartford Corp., 652 Franklin Ave., Hartford, Conn. B

is your problem

strength?

NATIONAL STEEL CASTINGS

are the answer



Nowhere is strength more important than in marine anchor chain. Resistance to corrosive salt water and resistance to abrasion between links are important, too. These properties, in full measure, are among the reasons why Naco cast steel anchor chain rates so high.

If these properties are important to your product, better look into steel castings by National. And remember, with National you get all the advantages of dealing with *one* strong company possessing the unparalleled facilities of *many* plants.

In brief, when you buy steel castings from National you get single-source responsibility with multiple-source flexibility.

AA-7460

IMPORTANT PHYSICAL PROPERTIES	
Brinell	140 to 500*
Yield, psi	30,000 to 210,000*
Ultimate, psi	60,000 to 240,000*
Elongation, %	24 to 2

*Depending upon grade

NATIONAL MALLEABLE and STEEL **CASTINGS COMPANY**

Established 1868

Cleveland 6, Ohio.

Circle 491 on Page 19

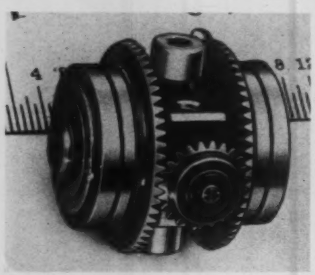
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Differential

is two-pinion, hollow-shaft unit

Developed for additive or subtractive operations, Model 36 miniature two-pinion, hollow-shaft differential functions as a precise analog component that accepts two variables as inputs. Variables may be in the form of angular shaft motion or shaft speed. Adding or subtracting these inputs, differential provides resultant as output shaft rotation. Use of hollow-spider shaft permits flexibility in positioning differential on output member. Shaft size for the unit is 3/16 in. Differential has low inertia and torque characteristics with minimum backlash. Maximum recommended gear-input speed is 1200 rpm with maximum static load of 6 oz-in. Principal application is in analog computing mechanisms, with other uses in fire-control mechanisms, flow-totalizing meters, rate-of-change computers, and other electromechanical equipment where shaft rotations are compared. **Commercial Div., Librascope Inc.,** 40 E. Verdugo Ave., Burbank, Calif. L

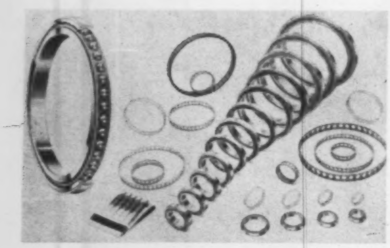


Circle 657 on Page 19

Thin-Section Bearings

have one-piece retainer and no loading slots

High-precision, thin-section, retainer-type instrument ball bearings are available in sixteen sizes with bores from $\frac{3}{8}$ to 3 1/16 in. Designated Type TCR, bearings have light, one-piece retainers with maximum ball complements, and continuous-race shoulders without filling slots, utilizing full thrust and radial capacity potential. Bearings are available in 52100 bearing steel or 440C stainless steel. Standard retainer is fiber-reinforced, pressure-molded phenolic, with stamped one-piece, stainless-steel retainers also available. Dimensions are to standards for AFBMA B-500 series. Bearings are for use wherever space and weight savings are important. **Split Ballbearing Div., Miniature Precision Bearings Co.,** Lebanon, N. H. B

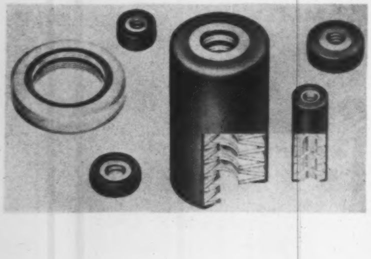


Circle 658 on Page 19

Spring Cartridges

have flexible elastic covering

Flexi-Pak spring cartridges are preassembled stacks of Belleville spring washers, held together by a flexible elastic covering. They are for applications where pins or rivets cannot be used to hold washers together because washer walls are too narrow, or where retaining rings or cores cannot be used because there is not sufficient vertical or radial clearance. Two types of covering are available—molded covering, cured around washers while they are under a slight load, and dipped or sprayed coating, applied to the stacks while they are held firmly together but relaxed. Units can be used to absorb shock, to exert large amounts of force within a limited space, to exert force at a low rate, and to maintain reasonably constant pressure in spite of expansion due to temperature variations. **Associated Spring Corp.,** Bristol, Conn. B

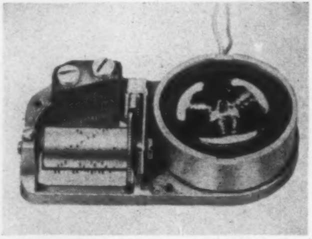


Circle 659 on Page 19

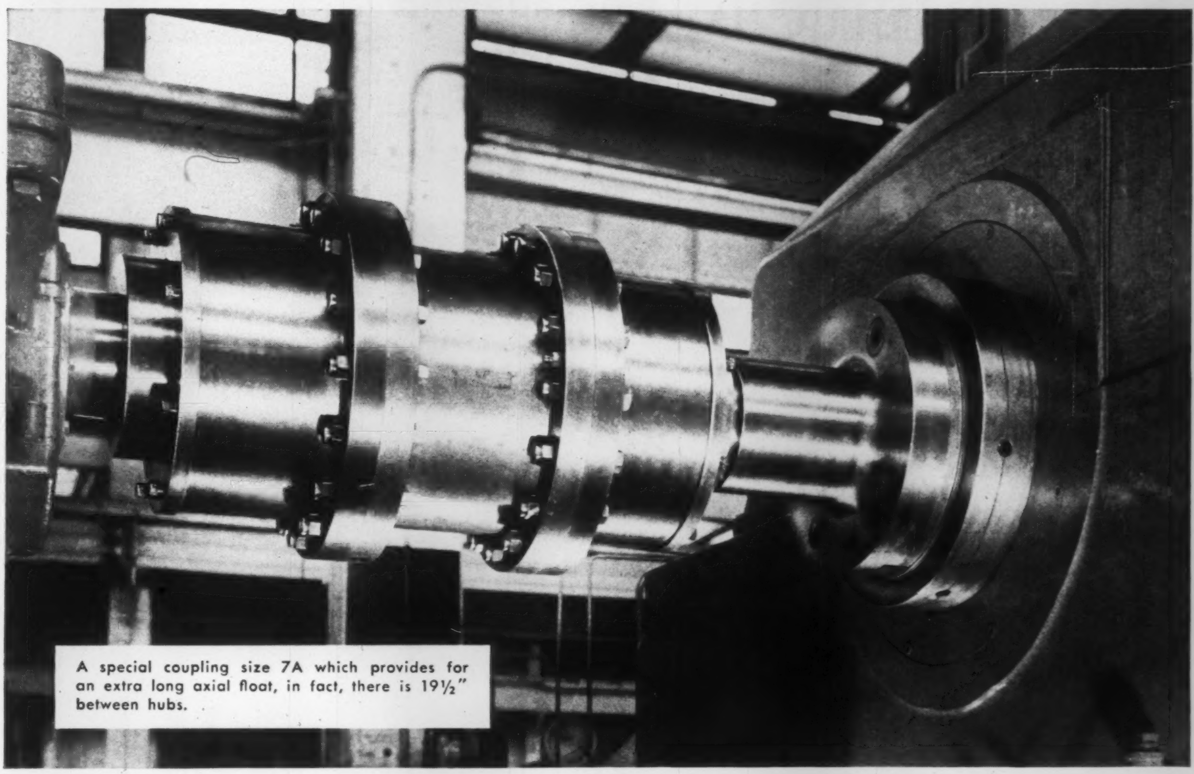
Miniature Motor

is designed for silent operation

New miniature electric motor, designated DCM2, utilizes a three-segmented flat commutator to provide extremely silent operation. Both ends of rotor shaft are mounted in combination journal and thrust bearings, embedded in soft rubber to further absorb noise and vibration. Entire motor is furnished in a plastic sound-absorbing case measuring $1\frac{1}{2}$ in. in diam by $\frac{3}{4}$ in. high. Weight is $1\frac{1}{2}$ oz. Free-running speed is 1200 rpm at 1.5 v dc. Motor is particularly suitable for tuning, recording, transmitting, musical, and other sonic devices. It is shown with cover off, used in conjunction with music-box mech-



SPECIAL COUPLING PROBLEMS



A special coupling size 7A which provides for an extra long axial float, in fact, there is 19½" between hubs.

SOLVED

at JOHN WALDRON

From time to time, manufacturers are faced with special power transmission problems which cannot be handled by standard couplings. Sometimes they need a coupling for exceedingly high speed drives, sometimes a coupling for very large diameter shafts and for other special applications.

John Waldron, which is well known for its ability to produce high quality couplings also makes excellent special couplings to customer requirements. In the past, Waldron has made couplings that turn at speeds over 50,000 RPM, couplings which can take over 45,000 HP and couplings for particular applications such as continuous lubricated couplings, spacer types, shear pins, cut-outs and couplings for many other special installations.

If you have a particular power transmission problem that needs a special coupling, call or write the John Waldron Corporation in New Brunswick, New Jersey. Their long experience in designing, and manufacturing couplings for special problems, may have already solved your problem for you.

JOHN **WALDRON** CORP.
A Subsidiary of Midland-Ross Corporation
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Circle 492 on Page 19

Give your design the advantages of

SYNCHRON® TIMING MOTORS

ADAPT- DEPEND- ability

SYNCHRON
TRADE MARK

UL and CSA approvals

Adaptability

Power-packed SYNCHRON Timing Motors are midget-sized to fit extremely close places. Adaptable to powering timing machines, action signs, recording thermometers, switches, heating and air conditioning devices.

Dependability

SYNCHRON Timing Motors pull up to 20 in. oz. at 1 r.p.m.; operate efficiently at temperatures from —40°F. to +140°F. Each motor must pass 51 inspections and a grueling test under power before shipment.

Every construction feature performance proven!

1 PATENTED TWO-PIECE FIELD STRUCTURE having wide and narrow poles, with rotor that rotates between inner and outer field poles. The inner and outer poles are properly shaded with heavy, continuous copper rings to assure maximum starting and running torque.

2 DOUBLE BEARINGS in reduction train on rotor shaft assure smooth operation.

3 ALUMINUM ROTOR RING SUPPORT.

4 PATENTED, HARDENED STEEL ROTOR RING.

5 OIL STORAGE RESERVOIR with patented oil feed to bearings.

6 HEAVY BRASS ROTOR COVER.

7 DOUBLE BEARINGS ON OUTPUT SHAFT.

8 GEAR CASE SEALED against oil leakage to permit mounting in any position.

9 FOUR CONVENIENT MOUNTING HOLES.

10 BRASS GEARS.

11 STEEL PINIONS. Note: Brass against steel assures longer life.

12 BAKELITE GEAR for quiet operation.

STANDARD TIMING MOTOR (8 IN. OZ.)	HI-TORQUE TIMING MOTOR (20 IN. OZ.)	SLO-MOTION SYNCHRON (1 R.P.H.)	HANSEN CLOCK MOVEMENTS	HANSEN MAGNA-TORC DC MOTOR
Compactly built to space saving dimensions, with rotor and coil packed in a sturdy hand - sized case. Used in timing devices and controls of all types. Guaranteed torque 8 in. oz. at 1 r.p.m.	There's big power packed into this versatile timing motor. One year guarantee. Dependable, accurate, trouble-free. Guaranteed torque 20 in. oz. at 1 r.p.m.	A new timing motor developed especially for slow motion jobs. Guaranteed 20 in. oz. at 1 r.p.h. (1/60 r.p.m.)	For standard and office clocks, sign clocks, novelty clocks, and clocks of all kinds up to 26″ in diameter under glass. Precision power with a Synchron timing motor.	Designed for aircraft instruments and radio controls. Armed Forces applications have proved its top performance worldwide under all operating conditions. Easily adapted to commercial uses.

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SYNCHRON®

"Workhorse of the industry"

synchronous motors, timing machines, clock movements, magnatorc DC motors

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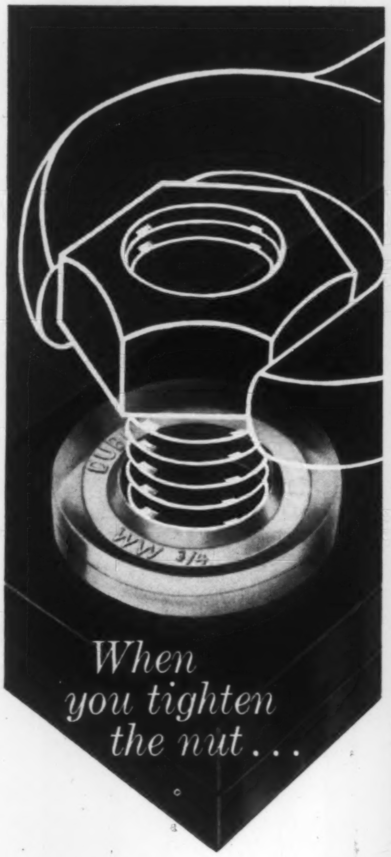
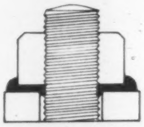
HANSEN REPRESENTATIVES: The Fromm Co., 5150 W. Madison St., Chicago, Ill.; Winslow Electric Co., New York, N.Y., Chester, Conn., Philadelphia, Cleveland; Electric Motor Engineering, Inc., Los Angeles WEBSTER 3-7591 and Oakland, Calif.; H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton and Schenectady, New York

Circle 493 on Page 19

This new lock and seal washer is just plain **REVOLUTIONARY...**


DUBO
WW 3/4
When you tighten the nut . . .

NYLOGRIP Dubo Lockwasher locks and seals it-instantly!



Patents Applied For

The new NYLOGRIP Dubo Lockwasher is made of a special, cold-flow plastic called Nylon 6. When the nut is tightened, the washer "flows" — its inner diameter grips into the threads of the nut and bolt, to seal this junction against leakage, while the outer diameter flows over the outer edges of the nut, seals and locks it . . . so tight neither shock nor vibration can budge it! The Dubo Lockwasher can be used time and again without the slightest loss of holding power. And, because it's symmetrical and has no threaded parts, you couldn't fit one incorrectly if you tried.

PLUS FEATURES: excellent electrical properties . . . exceptional wear resistance . . . good shock absorption . . . resists corrosion, chemicals . . . non-flammable . . . high flexural strength.

PLUS USES: The excellent electrical characteristics of NYLOGRIP Dubo Lockwashers make them ideal for electrical insulation, or to help control electrolytic corrosion between dissimilar metals.

YOU'LL WANT COMPLETE TECHNICAL INFORMATION.

Write today to:

NYLOGRIP PRODUCTS
445 Watertown St., Newton, Mass.-BI 4-0960
Non Metallic Fastenings of all types.

Circle 494 on Page 19

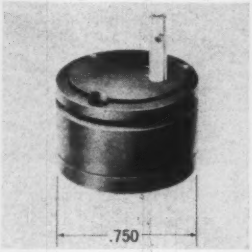
anism. **Moen Trading Co.,** 7 W. 24th St., New York 10, N. Y. C

Circle 660 on Page 19

Gear Boxes

mate with any Size 8 ac or dc motors

New Size 8 miniature gear boxes provide ratios from 1.5:1 to 600:1, depending on requirements. They mate with any standard Size 8 ac or dc motors, and can be adapted to any motor end configuration. Using Class 5 miniature bearings throughout, boxes have backlash as low as 45 min and handle 50 oz-in. torque. Starting torque is 0.015 oz-in. or less, depending on ratio required. Output-shaft diameters of 0.0937 and 0.1250 in. are available, and shaft is either concentric or offset with respect to housing. **Ellison Engineering,** 4350 San Fernando Rd., Glendale, Calif. L

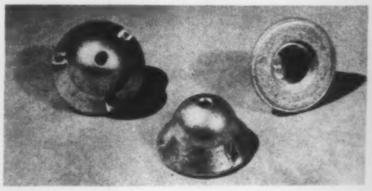


Circle 661 on Page 19

Cap Nut

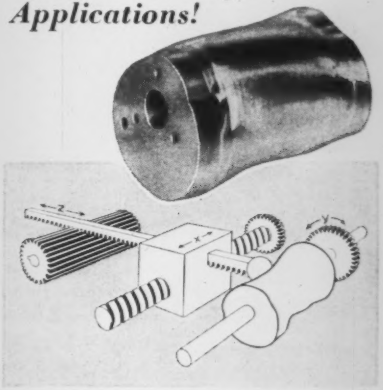
has tamperproof design

New tamperproof cap nut is a one-piece, die-cast, zinc alloy nut which can be removed from axle only with a special wrench. Base of nut is designed with a wide washer-type configuration having three notched recesses to accommodate special wrench. Sides of nut are sharply tapered from base to top, preventing pliers from securing a strong grip to loosen nut. Small hole in hub of nut provides for lubrication of axle after assembly. Fastener is now supplied in ¾-in.



MECHANICAL 3D CONTROL

Has Advantages in Thousands of New Applications!



3 Dimensional Cams can be used in applications where "x" and "y" are input variables of

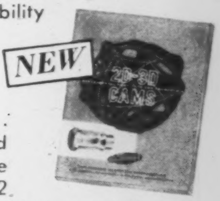
- temperature
- liquid flow
- speed
- pressure
- R.P.M.
- altitude

or any of thousands of other forces or motions.

"z" is the instantaneous resultant or readout of the two input variables. z = f(x,y).

Some advantages—

- withstand severe environmental extremes
- fidelity of readout
- smaller control size
- lighter control weight
- dependability



NOW AVAILABLE . . . the latest and most complete brochure on 2 and 3 dimensional cam control. Fully illustrated and diagrammed design, development, application information. Send for your copy today!

THE PARKER-HARTFORD CORPORATION
Franklin Avenue Hartford, Connecticut

Circle 495 on Page 19

#55 FACED MECHANICAL SEALS RESIST WEAR AND CORROSION

SEAL RING
CARBON INSERT SEAT
#55 FACING MATERIAL

A new and superior facing material is now available on the engineered mechanical DURA SEAL. #55 faced seal rings are long-wearing, operate at extremely high or low temperatures, and present highest resistance to wear and corrosion. #55 Facing Material combines the low-friction benefits of ceramic materials with the strength and resistance of alloyed steels.

THIS BULLETIN TELLS THE STORY
. . . For further details write today for a copy of Bulletin No. 469-MD

*ROKIDE Process Coating developed by the Norton Co. of Worcester, Mass.

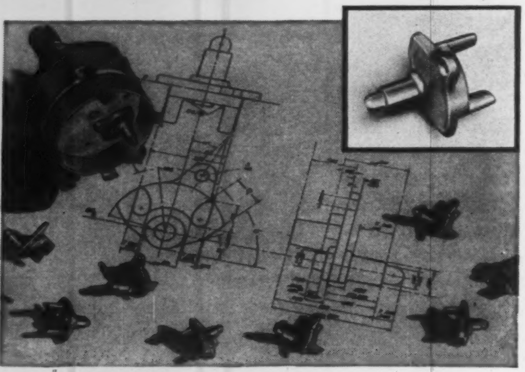
DURAMETALLIC The PERFECT SEAL CORPORATION
KALAMAZOO MICHIGAN

Circle 496 on Page 19

"IMPOSSIBLE" PART

die cast for MALLORY by GRC

helped create higher rated, longer lasting switch



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GRC
zinc die castings

"Impossible", yes, by *any other* method. BUT—GRC's unique single cavity die casting techniques made possible a detailed and complex actuating mechanism, with exceptional requirements of uniformity and accuracy. Inspired Mallory engineers to design a *new* and *better* switch around this GRC die cast mechanism! Just another instance in which GRC's exclusive patented methods have solved a parts problem and opened the door to a new product . . . at substantial savings.

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GRIES REPRODUCER CORP.
WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS
32 Second St., New Rochelle, New York • NEw Rochelle 3-8600

Circle 497 on Page 19

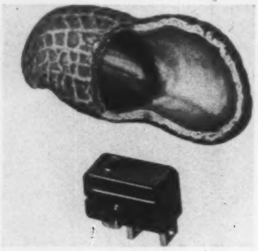
size with No. ½-13 thread; other sizes will be made available. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N. Y. D

Circle 662 on Page 19

Subminiature Switch

has only one moving part besides button

Peanut subminiature basic switch has long mechanical and electrical life, no dead break for sensitive application, and high repeatability with only one moving part besides button. It is available with any standard actuator, and uses a No. 1 screw bolt passing through in-line holes in switch for ganging. Base size is 0.526 in. long, 0.250 in. wide, and 0.323 in. high; weight is 1.7 grams. Ambient temperature range is −65 to 250 F. Electrical ratings are: 6 amp, 125/250 v ac, 30 v dc resistive; 3.5 amp, 30 v dc inductive, sea level; 3.0 amp, 30 v dc inductive, 50,000 ft; and 2.5 amp, 30 v dc inductive, 100,000 ft. **Switch Div., Electrosnap Corp.**, 4230 W. Lake St., Chicago 24, Ill. J



Circle 663 on Page 19

Electric Counter

has full-wave rectification for ac operation

CE-800 Wizard electric counter incorporates a built-in silicone diode full-wave bridge rectifier with capacitor to make possible maximum reliability and service life through all ac voltages to 230 with 25, 40, and 60-cycle frequencies. Die-cast aluminum housing with gasket seal and cement-sealed staked window assures maximum protection against dust. Conduit opening with separate wiring compartment permits wiring without breaking dustproof enclosure seal. Rated at 1000 counts per minute, the unit op-

erates reliably at higher speeds with electronic actuation. **Production Instruments Div., General Controls Co.,** 8062 F PH McCormick Blvd., Skokie, Ill. J

Circle 664 on Page 19

Sand-Casting Alloy

combines high strength and excellent ductility

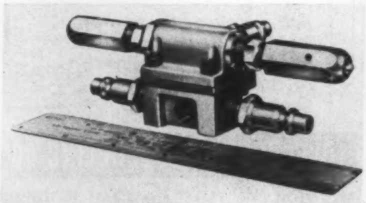
X250-T4 aluminum sand-casting alloy provides high resistance to stress corrosion and retention of high ductility during natural aging. Typical applications include aircraft structural castings, construction or mechanical equipment subject to impact loads, and equipment for dairy, food, and chemical industries. Alloy provides excellent resistance to industrial and marine atmospheres. Developed to replace alloy 220-T4, it is available with the same minimum tensile properties. **Aluminum Co. of America,** Room 745, Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 665 on Page 19

Miniature Valve

can be remote-controlled

No. 420 four-way miniature valve, connected through 1/4-in. plastic hose, can be placed at some distance from main valve and can be remote-controlled. Valve has 1/8-in. apertures, and has no neutral positon. It can be mounted in tight corners or inaccessible spots, but controlling limit valve can be placed within easy reach. Body is die-cast, fittings are brass, and replaceable



Revolutionary Wire Cloth Looms use Wood's Timing Belt Drives to cut rejects . . . speed output

New, radically different wire cloth looms, developed by New York Wire Cloth Company, not only weave screening of exceptional quality, but increase production 50% or more.

An important factor in minimizing defects and maintaining output is Wood's Timing Belt drive. The slip-free, positive action of this drive, together with no belt stretch, eliminate irregularities of mesh . . . help maintain operating speeds never before possible. The compact Wood's Timing Belt drive is used in this loom to replace a multiple V-belt drive. Not only does it satisfy the high efficiency requirements and eliminate matching of belts, it has long life and requires no maintenance, features which permit its use in a relatively inaccessible area.

Wood's Timing Belt drives have a wide range of load capacities, up to 600 hp and above, and cover an exceptional speed range, from zero to 16,000 fpm. Absence of metal-to-metal contact eliminates the need for lubrication. These and many other features make this drive outstanding for a wide variety of applications.

Contact your T. B. Wood's representative for complete information and your copy of Catalog 2100.

V-BELT DRIVES • VARIABLE SPEED DRIVES • TIMING BELT DRIVES • CARD DRIVES • FLEXIBLE AND RIGID COUPLINGS • FLYWHEELS • PULLEYS • MOTOR BASES • BALL BEARING PILLOW BLOCKS, FLANGE UNITS AND TAKE-UP BEARINGS • BABBITTED AND BRONZE BEARINGS • DUCTILE IRON PRODUCTS

Wood's

T. B. WOOD'S SONS COMPANY
CHAMBERSBURG, PENNSYLVANIA

ATLANTA • CAMBRIDGE • CLEVELAND • DALLAS • NEWARK

Circle 498 on Page 19

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- Solid race construction
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A PRODUCT OF
SEALMASTER BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
18 RIDGEWAY AVE. • AURORA, ILL.

Circle 499 on Page 19

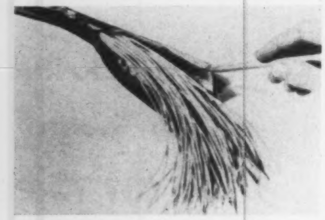
wear plate is hardened noncorrosive metal. **Mead Specialties Co.**, Dept. MV-25, 4114 N. Knox Ave., Chicago 41, Ill. J

Circle 666 on Page 19

Zippered Tubing

is available in shielded types

New Zippertubing is available with copper, aluminum, and Co-netic steel shielding for regular or magnetic shielding use. A radiation material of vinyl-covered, lead-saturated glass cloth is also available to protect cables, wires, and controls from nuclear radiation. Shielded Zippertubing is offered in IDs from



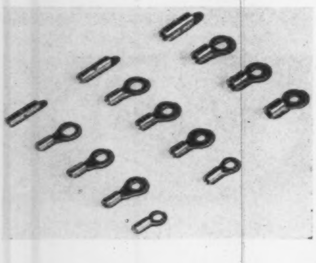
3/8 in. up in increments of 1/8 in. The gray tubing is available in standard lengths of 25, 50, 100, and 300 ft. **Zippertubing Co.**, 752 S. San Pedro St., Los Angeles 14, Calif. L

Circle 667 on Page 19

Terminals and Connectors

solderless units are for high-temperature uses

New solderless, high-temperature terminals and connectors, designated Temp-Terms, are high-conductivity, heat-resisting alloy, nickel plated to provide resistance to corrosion. They are rated for continuous duty at 650 F. Ring terminals and butt connectors are available in No. 6, 8, and 10 screw sizes for wire ranges 22-16, 16-14, and 12-10. Units permit fast, positive, permanent connections, and are of one-piece construction. In-



Lovejoy

Maintenance-Free FLEXIBLE COUPLINGS

Standard Duty Types .05 to 40 hp. at 1750 rpm.

Medium and Heavy Duty Types 2.6 to 810 hp. at 100 rpm.

Radially Removal Types 1.9 to 30 hp. at 100 rpm.—2 to 40 hp. at 1800 rpm.

Flange-Mounted Types 11 to 740 hp. at 900 rpm.

Put Trouble-Free Performance Into Your Equipment

COMPARE THESE FEATURES:

- A type and size perfectly suited to your application.
- Year-after-year dependability, regardless of load or operating conditions.
- Completely machined for ease and speed of alignment.
- No lubrication required.
- Simple, rugged construction—few parts and no intricate mechanisms.
- Cushioned power transmission—load is transmitted through cushioning materials—no wear on the metal jaws.
- Double-life cushions—one half the cushions act as idlers, except on reversing loads—quick interchange provides a new set of cushions.
- Cushions are engineered to the load and service conditions.

● *Ask Lovejoy to recommend the exact flexible coupling for your application. No obligation. Request catalog.*

LOVEJOY FLEXIBLE COUPLING CO.
4818 WEST LAKE STREET • CHICAGO 44, ILLINOIS

Circle 500 on Page 19

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ELECTRICAL ENGINEERS

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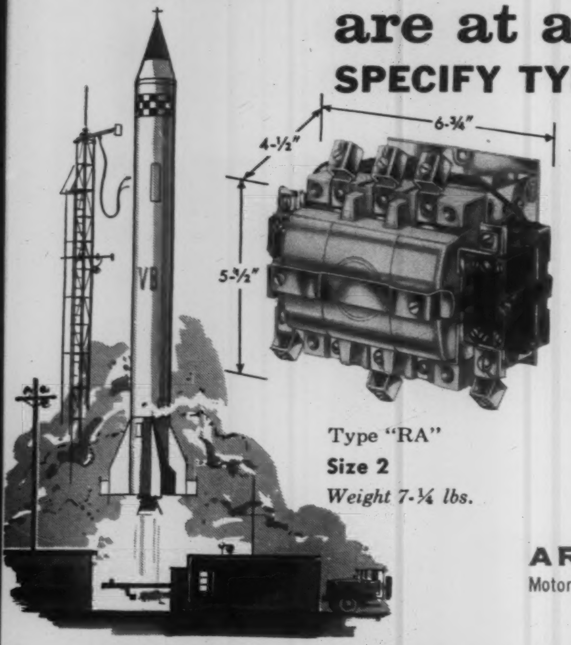
Here's your chance to break in on a growing field where aggressive creative work is really appreciated. MACHINE DESIGN has a staff opening for an engineer with an interest in both engineering and editorial work. This job provides stimulating contact with many engineering areas plus opportunity to grow and progress as a specialist in a particular branch of design engineering.

Some evidence of design engineering experience is necessary, and an ME or EE degree would be desirable. Writing ability and interest are also required, although a heavy background of editing or writing is not essential.

Salary will depend on experience; progress for the right man can be rapid. Headquarters are in Cleveland with opportunities for travel to attend engineering meetings and expositions.

If you are interested, send full details of your engineering background to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.



Whenever SPACE and WEIGHT are at a Premium...

SPECIFY TYPE "RA" MOTOR CONTROLS

Launching, guidance, tracking and service equipment for rockets or guided missiles *MUST* pack the greatest possible performance capacity into the smallest possible envelope. That's why Arrow-Hart Type "RA" Starters and Contactors have been selected for so many rocket and missile projects . . . and so many other applications where space and weight savings are all-important. Far smaller and lighter than conventional types, Arrow-Hart "RA" Controls use advanced design with greatly improved mechanical efficiency to achieve superior performance and dependability. The modern Right Angle operating mechanism insures positive operation and provides increased resistance to unfavorable atmospheric conditions.

For "RA" Data Section, write now to The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

Type "RA"
Size 2
Weight 7-¼ lbs.

ARROW – HART OF HARTFORD
Motor Controls • Wiring Devices • Appliance Switches • Enclosed Switches

Circle 502 on Page 19

ARROW AH HART

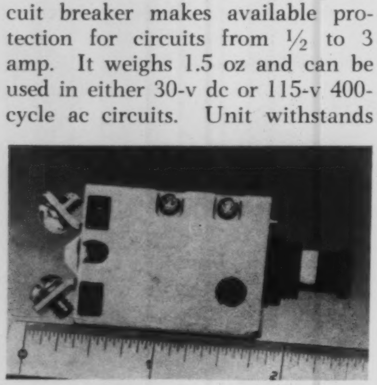
terior barrel grooves and V-notches firmly hold wire in place. Connections are vibrationproof and moisture-tight. **Electrix Terminals & Connectors Inc.,** 990 E. 67th St., Cleveland 3, Ohio. G

Circle 668 on Page 19

Circuit Breaker

miniature unit protects low-amperage equipment

MP-1500 miniature, fast-acting circuit breaker makes available protection for circuits from ½ to 3 amp. It weighs 1.5 oz and can be used in either 30-v dc or 115-v 400-cycle ac circuits. Unit withstands extreme environmental conditions in accordance with specification MIL-C-5809. It is shock and vibration resistant and is unaffected by changes in ambient temperature. Particularly useful in aircraft, unit is also effective for protection of circuits in missile ground-control equipment, communications equipment, radar, power supplies, instruments, and electronic and testing equipment. Breaker can be opened and closed manually as a switch. It is tripfree and cannot be held closed against overload. **Mechanical Products Inc.,** 1800 River St., Jackson, Mich. H

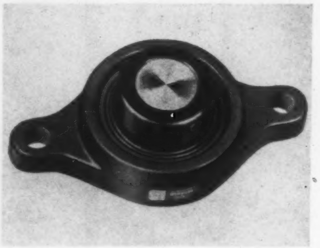


Circle 669 on Page 19

Flange Block

is two-bolt type

FB210 series two-bolt flange block has unbreakable malleable housing and bearings lubricated for life. It is available in 16 shaft sizes from ½ to 1 7/16 in. Unit is an eccentric locking-ring type which fits in a limited space. Blocks range in length from 3 13/16 to 6 3/16 in., in width from 1 15/16 to 3⅜ in., and in depth from 1 19/64 to 1 11/16 in. **Browning Mfg. Co.,** Maysville, Ky. G



Circle 670 on Page 19

Silicone Rubber Compounds

for low-temperature use

Two new silicone rubber compounds, suited for aircraft and missile use, are readily adaptable to requirements of other industries. SE-525 is a tough 25-durometer compound for molded and extruded seals, low-pressure gaskets, cushions, and other parts. It offers tensile strengths to 1000 psi, elongation to 700 per cent, and Die B tear strengths to 100 lb per in.

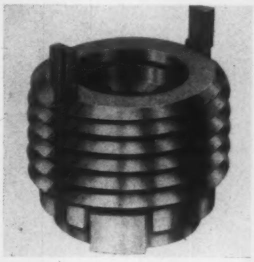
Compound surpasses requirements of AMS 3332. SE-567 is also a low-temperature service compound of 60-durometer hardness. Possessing good flame retardancy, it is suited for airframe seals and wire and cable applications where resistance to flame is required. Both compounds have excellent handling characteristics and can be molded and extruded by standard techniques. They can be pigmented in a variety of colors. **Silicone Products Dept., General Electric Co.,** Waterford, N. Y. C

Circle 671 on Page 19

Self-Aligning Insert

is internally threaded

Keensert self-aligning, internally threaded insert compensates for misalignment of bolt holes in mating parts. One-piece unit can be screwed by hand into tapped holes prepared with standard drills and taps. Units provide maximum resistance against pull out. Positive mechanical resistance to rotation is provided by inserts pressed into base material with a small punch and hammer or an installation tool. Prevailing torque is extremely consistent after repeated installations and removals of the bolt. **Newton Insert Co.,** 6500 Avalon Blvd., Los Angeles 3, Calif. L



Circle 672 on Page 19

Laminated Plastic

resists high temperatures

Phenolite Grade GH-871 laminated plastic, constructed from glass fabric combined with high-temperature-resisting phenolic resin, is designed for short-time applications such as parts for guided missiles or rockets. It retains more than 95 per cent of its strength after ½-hr exposure at 500 F, and withstands higher temperatures for shorter time periods. Material has excellent mechanical and electrical properties. It is available in sheet sizes of 39 in. square and 39 x 47 in., in thicknesses from 1/16 to ½ in. Color is dark brown and finish is semigloss. **National Vulcanized Fibre Co.,** 1058 Beech St., Wilmington 99, Del. C

Circle 673 on Page 19

Flowmeters

have − 350 to 300 F temperature range

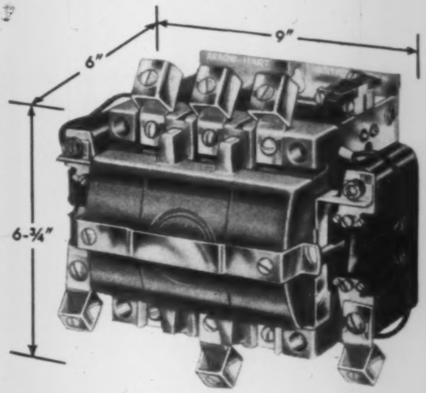
New flowmeters, providing both rate and totalizing indication, feature pressure drop of less than 2.5 psi and transmitter accuracies of ± 1 per cent over range from 3 to 600 gpm. Units are available in stainless steel or aluminum alloy, and have a temperature range of − 350 to 300 F. They accommodate a variety of exotic and special fluids, in addition to conventional fuels and hydraulic fluids. Pickoff design produces a gated 400-cps output of 2.5 v regardless of flow rate, cancels

MOTOR CONTROLS

SMALLEST Magnetic Starters Available!

Arrow-Hart Type "RA" Motor Controls feature the advanced design "Right Angle" mechanism, with the magnet operating through a simple bellcrank mechanism. This provides a mechanical advantage making possible a much smaller and lighter magnet which out-performs older, direct-acting types. As a result, size and weight are reduced by almost half, while performance, operating efficiency and dependability are greatly improved. Other important "RA" design features include extra-rugged silver cadmium alloy contacts with positively guided travel for perfect alignment . . . and straight-thru wiring for simplified circuit design.

Arrow-Hart offers you the *only* complete line of smaller, lighter motor controls including: NEMA Sizes 0 through 5, in across-the-line, reversing and two-speed starters and contactors.



Type "RA" Starter
Size 3
Weight 15-½ lbs.

Write for free 16 page booklet of Motor Control Wiring Diagrams: The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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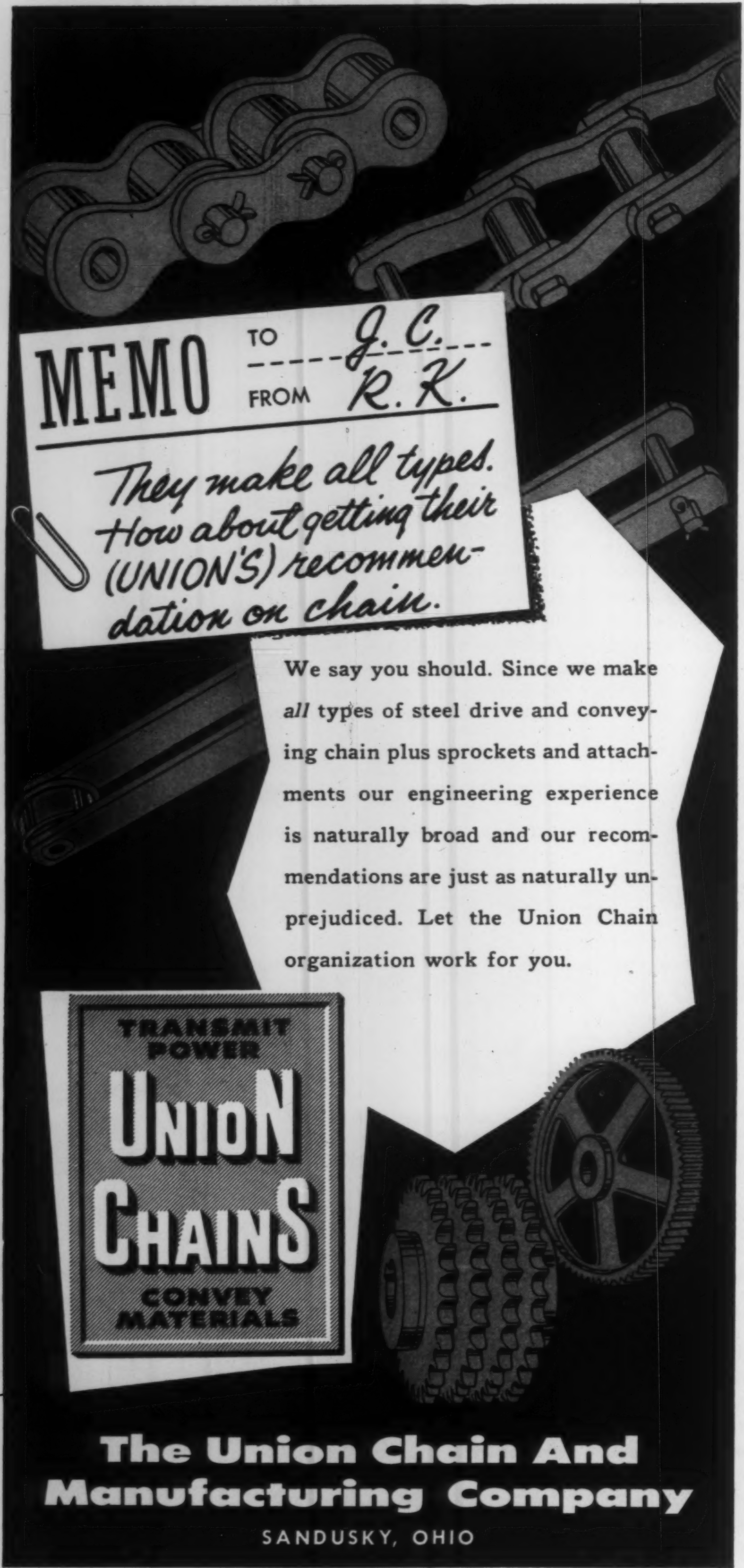
Circle 503 on Page 19


MEMO TO J.C.
FROM R.K.

They make all types. How about getting their (UNION'S) recommendation on chain.

We say you should. Since we make *all* types of steel drive and conveying chain plus sprockets and attachments our engineering experience is naturally broad and our recommendations are just as naturally unprejudiced. Let the Union Chain organization work for you.

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The Union Chain And Manufacturing Company
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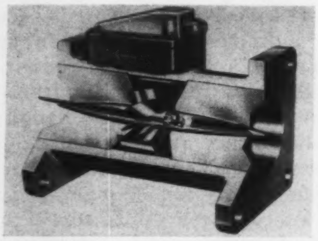
Circle 504 on Page 19



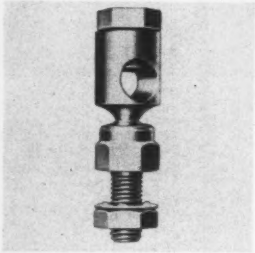
out effects of stray electrical fields, and produces a large signal-to-noise ratio. Typical unit for 2-in. line is shown. **Revere Corp. of America,** Wallingford 2, Conn. B

Circle 674 on Page 19

Ball-Joint Assembly

uses setscrew to
lock joint

Type DC ball-joint assembly incorporates a hardened, self-locking, hexagon-head setscrew which locks ball joint anywhere along length of unthreaded rods. Screw is firmly locked in position, and will not loosen under vibration. Larger thread permits greater assembly torque and holding strength over spring-clip construction. Available for 1/4 and 5/16-in. diam rods in several thread sizes, assembly has many linkage-control applications. **Superior Ball Joint Corp.,** 8906 Trier Rd., Ft. Wayne, Ind J



Circle 675 on Page 19

Variable-Speed Pulley

cam-controlled unit
gives constant speed ratio

Constant speed ratio can be maintained positively over a wide range of load variation by means of a cam-controlled variable-speed pulley. Unit employs cam and cam-follower assembly, designated Load-O-Matic, which automatically regulates belt tension to exact requirements of load. Pulley speed is made independent of load and load

Engineered by Tinnerman...

Train maker cuts assembly costs 37%
with one-piece Tinnerman **SPEED CLIPS®**

On Lionel electric trains, one-piece Tinnerman SPEED CLIPS fasten car trucks to car bodies... cut assembly costs 37%. Each SPEED CLIP replaces a grooved screw-machine part and a special retainer ring. Also eliminated are riveting and crimping operations.

Specially engineered for Lionel, this SPEED CLIP is easily snapped through punched holes. Spring steel fingers compress, then spring apart to complete the truck-to-body attachment.

Perhaps your product can be assembled faster, better, at lower cost by a switch to Tinnerman SPEED NUT brand fasteners. Your Tinnerman sales engineer can make on-the-spot fastening recommendations. Or he can arrange for a complete no-obligation Tinnerman Fastening Analysis of your product. He's listed in the Yellow Pages under "Fasteners." Or write to:

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FASTEST THING IN FASTENINGS®

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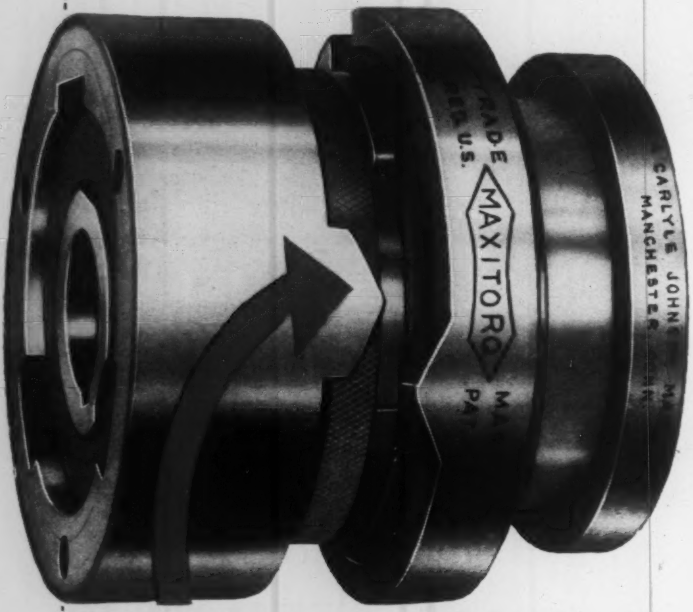
Circle 505 on Page 19

PLUS protection against overload



Maxitorq

overload release clutches

Designers and builders have found MAXITORQ Overload Release Clutches the ideal way to provide dependable protection against overload conditions.

Unlike such devices as shear pins, the MAXITORQ Overload Release Clutch requires no dis-assembly or replacement after functioning. Once the cause of overload is removed or corrected, the machine may be re-started at once. Furthermore, MAXITORQ Overload Release Clutches may be adjusted for pre-determined overload protection.

In addition, users enjoy the proved advantages of the MAXITORQ Floating Disc Clutch . . . smooth, positive engagement and release . . . "floating" neutral with no drag or heating . . . easy manual adjustment.

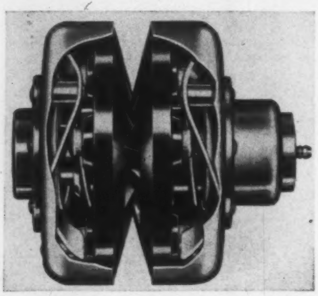
We will be glad to give you the benefit of our long and successful experience in clutch and brake design; the overload release clutches are only one of many advanced MAXITORQ developments in both manual and electrically operated applications. Ask for literature, or outline your problem . . . write Dept. MD-9.

THE CARLYLE JOHNSON MACHINE CO.
Manchester, Connecticut

2CJ58

Circle 506 on Page 19

variations, drag is eliminated, and high shock absorbency is provided. Each of two driving discs contains its own cam and cam-follower assembly, so that pulley is double cam-controlled. Pulley is available in sizes from 0.5 to 5 hp in ratios 2.5:1 (single pulley) and 6.25:1 (double pulley). **Lovejoy Flexible Coupling Co.**, 4932-H W. Lake St., Chicago 44, Ill. J

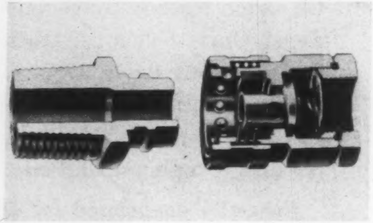


Circle 676 on Page 19

Quick-Connect Couplings

for use with reciprocating air tools

IH quick-connect, quick-disconnect couplings, for use with reciprocating air tools, deliver more air with minimum pressure drop. Center-type valve gives 360-deg contact with nipple, permitting repeated valve opening and closing. Couplings are available only with valved coupler and plain nipple, and are supplied with male or female NPT, hose shank, AND 10056 male or 10050 female, or AND 10057 bulkhead end connections. Sizes are $1/8$ to $1/2$ in. in cadmium-plated alloy steel. **Snap-Tite Inc.**, 201 Titusville Rd., Union City, Pa. F



Circle 677 on Page 19

Laminated-Plastic Tubing

has minimum ID of 0.050 in.

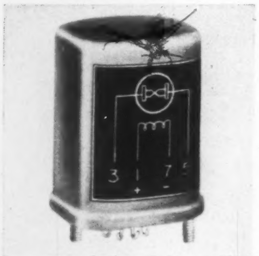
Rolled laminated-plastic tubing is now available with minimum ID of 0.050 in. Small tubing meets requirements of applications such as terminal insulators, contact pins, and parts for transistors, rectifiers, diodes, and resistor tubes. Sizes below 0.125 in. are furnished in Grade XX laminated plastic, a paper-base, phenolic-resin grade with good electrical, mechanical, and physical properties. Maximum ID for rolled tubing is 36 in. **Taylor Fibre Co.**, Norristown, Pa. E

Circle 678 on Page 19

Electronic Relay

has no moving parts

New relay is completely potted and withstands any shock or vibration now being encountered. Electronic coil circuit operates on 28 v dc, pulls in at 18 v and drops out at 7 v or less with positive snap action. Coil circuit is completely isolated from electronic switching circuit. Unit switches either ac or dc, has transfer time of less than 50 mu sec, and no contact bounce. It has no arcing or contact contamination. **Pendar Inc.**, 6049 W. Adams Blvd., Los Angeles 34, Calif. L

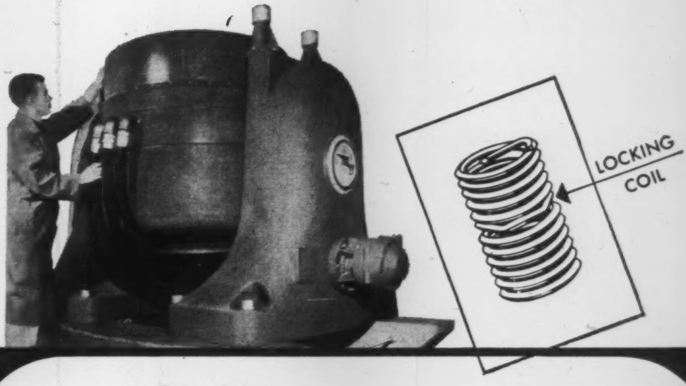


Circle 679 on Page 19

Drives and Couplings

available with ratings from ¼ to 1000 hp

Added to a line of Flexidyne dry-fluid drives and couplings are three larger sizes, and a small size for low-power applications. An 18-in. diam unit is available either as a drive for use with V-belts, or as a coupling for direct shaft-to-shaft connection. Either delivers up to 200 hp at 1200 rpm. A 22-in. size, available only as a coupling, transmits up to 800 hp at 1200 rpm. Largest of the units is a 27-in. coupling with rating up to 100 hp at 900 rpm. Applications for the larger sizes include conveyors, fans, processing machinery, chippers,



Why this
CRITICAL VIBRATION TEST EQUIPMENT
USES **HELI-COIL*** SCREW-LOCK INSERTS
—to hold parts securely
under extreme shock and vibration

*Reg. U.S. Pat. Off.

Currently the world's highest force electro-dynamic vibration exciter, the MB Model C250, made by the MB Manufacturing Co., is vital to government research in today's air age . . . has a frequency range of 2-500 cps., and a total force output of 25,000 lbs. It can be adapted to operate in chambers where temperatures range from −100°F to 300°F and simulated altitudes hit 125,000 feet.

Test specimens of up to 2190 lbs., subjected to accelerations of 10 g., must be securely held to the unit's moving assembly.

The thread assemblies within the vibrator, and joining test specimens to the unit, are subjected to grueling shock and vibration. Yet, even under these extreme conditions, *Heli-Coil* Screw-LOCK Inserts (277 of them) function perfectly . . . protect threads against stripping . . . hold fasteners securely.

Meeting military specifications for torque and vibration, this new, one-piece stainless steel Screw-LOCK Insert:

1. positively locks screws against loosening under impact and vibration
2. prevents thread wear, stripping, corrosion, galling, seizing
3. eliminates the need for lock-nuts, lock-wiring, and other supplementary locking devices
4. offers high re-usability on repeated disassembly and reassembly.

Heli-Coil Screw-LOCK Inserts are available in many sizes, including the new miniature 4-40. For further information, write 4227

HELI-COIL CORPORATION
A Division of Topp Industries, Inc.

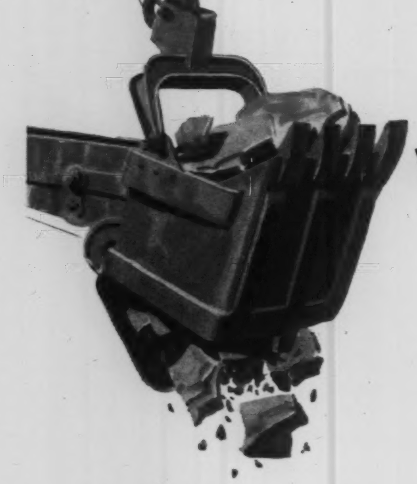
HELI-COIL CORPORATION
509 Shelter Rock Lane, Danbury, Conn.

☐ Send me complete design data on *Heli-Coil* Screw-LOCK Inserts.
☐ Who is my local *Heli-Coil* Applications Engineer?

NAME________ TITLE________
FIRM________
ADDRESS________
CITY________ ZONE____ STATE________

IN CANADA: W. R. WATKINS CO., LTD., 41 Kipling Ave. S., Toronto 18, Ont.

Circle 507 on Page 19



BUYING A NEW SHOVEL OR DRAGLINE?

National Torque Converters are available as original equipment on many leading makes

REPOWERING YOUR PRESENT SHOVELS?

National Torque Converters are available "packaged" or matched with virtually all leading excavator engines

When you have to figure close on a contract job . . . a little extra efficiency in the equipment can make the difference between a loss and a profit.

The National Torque Converter gives this all-important extra. It *takes in* power with the engine working at its most efficient speed and output range. It *delivers* the power at speeds and torques best suited to each operation. It multiplies the torque and so boosts line pull or bucket push, up to three times that available from the unaided engine. It's like having an extra engine when you need it.

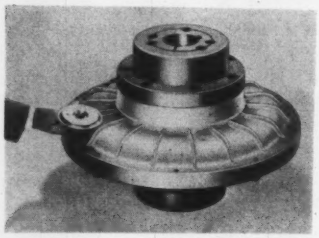
You can get these advantages on new equipment . . . for the converters can be specified for original installation on most leading makes. You can get them in repowering old equipment . . . for National Torque Converters are available packaged with many leading makes of diesels . . . and perfectly matched to the rest.

For information . . . just write:

THE NATIONAL SUPPLY COMPANY
INDUSTRIAL PRODUCTS DIVISION
Two Gateway Center, Pittsburgh 22, Pa.
Pace-setters in the progress of industrial power transmission

THE NATIONAL SUPPLY COMPANY NSCO

Circle 508 on Page 19



mixers, wire and tube-drawing machines, pumps, crushers, hogs, and pulverizers. For medium-light applications such as cranes, fans, and small conveyors, a 6-in. unit is provided. Available as a coupling or for use with V-belt drives, it is rated at up to 2 hp at 1800 rpm. Full line now available consists of eight drives and 10 couplings, ranging in capacity from 1/4 to 1000 hp. **Dodge Mfg. Co.**, Mishawaka, Ind. J

Circle 680 on Page 19

Oil-Pressure System

for pressures to 250 psi

CircOilator is a compact unit which maintains controlled volume and pressure of oil for stuffing boxes. Designed particularly for stuffing boxes containing double mechanical seals, it is also adaptable for conventional packaging, bearings, and other hydraulic requirements. System consists of 18-gal tank, pump, motor, pressure regulator for pressures to 250 psi, filter, tank breather, and relief valve. Two units have maximum volume of 1/2 and 1 1/2 gpm, and 1/2-hp motors are rated 3 phase 220/440 v 1800 rpm. **Durametallic Corp.**, 2104 Factory St., Kalamazoo, Mich. H

Circle 681 on Page 19

Proximity Switch

is vane operated

New vane - operated proximity switch which requires no separate

We fabricate in more than 200 different materials*

GASKETS PACKINGS WASHERS
SEALS SHIMS BUSHINGS "O" RINGS

If it's a problem of the right material for the job—at the right price—Auburn is sure to have the perfect solution among the wide range of materials in which we work.

Put our 87 years experience to work for you—Auburn's engineers are tops in their field in designing and fabricating precision sealing devices. Their know-how is at your command. "O" Rings are a speciality with us.

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Silicone Rubber • Neoprene • Rubber • Cork
Fibre • Compositions • Phenolics • Cloth • Felt
Paper • Cardboard • Plastics • Brass • Steel
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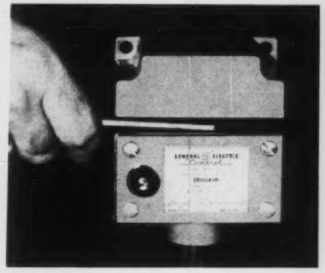
AUBURN
MANUFACTURING COMPANY
303 Stack St., Middletown, Conn.

New York, N. Y.; Rochester, N. Y.; Detroit, Mich.; Chicago, Ill.; Minneapolis, Minn.; Pittsburgh, Pa.; Cincinnati, Ohio; Ridgewood, N. J.; Atlanta, Ga.; Memphis, Tenn.; St. Louis, Mo.; Camden, N. J.; Washington, D. C.

Circle 509 on Page 19

power supply is for use in controlling machinery travel. Unit is capable of over 250,000,000 operations with General Electric static control. Armless, leverless, and shaftless, the magnetic device is energized by passage of a separate metal vane through a recessed slot in switch. Attached to the mechanism to be controlled, vane disturbs magnetic field balance which causes two small contacts to operate. Effect of normal stray magnetic fields and presence of magnetic dust and chips in slot will not cause false operation. Operation remains consistent within ±0.0025 in. providing position of vane is maintained. Response time is approximately 0.001 sec. Rated 115 v ac and 0.2 amp make or break, the single-pole, single-throw unit meets JIC requirements. It is available in normally open and normally closed forms with or without neon indicating light. Switch operates at any angle. **General Purpose Control Dept., General Electric Co.**, Schenectady 5, N. Y. C



Circle 682 on Page 19

Transistorized Amplifiers

amplify signals from
high-impedance transducers

New transistorized amplifiers, one-third the size of equivalent tube-type units, need no filament power and only 20 per cent of plate power required by tube-type units. The instruments amplify signals from high-impedance transducers to feed directly into standard electronic meters, recorders, or telemetry equipment. Operating at a temperature range of −65 to 240 F, amplifiers are low microphonic voltage units designed for use in missiles, aircraft, and other devices where size, weight, and power consumption are important factors. High input impedance and continuously variable

LimiTorque ACTUATORS

LIMITORQUE
PHILADELPHIA GEAR CORPORATION
PHILADELPHIA PA

for UP OR DOWN OR ROTARY POSITIONING

LimiTorque actuators are efficient, sensitive, automatic heavy duty power-operated units for positioning machine parts or other assemblies requiring Linear or Rotary Motion.

LimiTorque is an electro-mechanical mechanism, using motor power through highly efficient and precision gearing, to impart Linear or Rotary motion . . . Limit switches are available to limit the travel in either direction—Thrust and Torque responsive switches control thrust or provide emergency shut-off. With LimiTorque it is possible to control full travel accuracy to within .2%—LimiTorque is easily and accurately controlled by the mere "push of a button".

LIMITORQUE IS BACKED BY 30 YEARS' EXPERIENCE IN MOTORIZING ALL TYPES OF VALVES—WHY NOT CONSULT US REGARDING ANY PROBLEM YOU MAY HAVE INVOLVING LINEAR ACTUATION; OUR ENGINEERS CAN NO DOUBT HELP YOU SOLVE THAT PROBLEM.

LimiTorque
PHILADELPHIA GEAR CORPORATION
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
Offices in all Principal Cities
INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID MIXERS • FLEXIBLE COUPLINGS
Limitorque Corporation • Philadelphia

Circle 510 on Page 19

from the **BOARD** to the **ASSEMBLY LINE**

DPS has

the technical know-how to "engineer" more speed and profit into your assembling operations.

● The signal success of DPS trained engineers in adapting power equipment to the individual feeding and assembling needs of industrial plants everywhere is assurance that they can likewise solve your special problems. In our broad line of

SELECTIVE PARTS FEEDERS
POWER SCREWDRIVERS
SPECIAL ASSEMBLING MACHINES

equipment can be selected, and custom features incorporated, to fit your requirements. Plan now to use DPS modern assembling methods. Tell us your set-up. Write for catalog and further details.

POWER SCREWDRIVERS
An extensive, versatile line in both bench and pedestal types.

BOWL FEEDER
Electrical vibratory type to feed parts that cannot be tumbled.

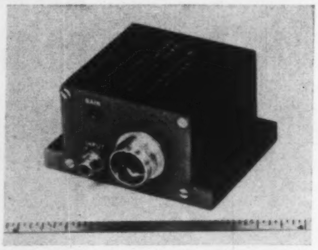
BARREL FEEDER
with stationary ring cover for heavy-duty production.

BARREL FEEDER
Popular motorized type, for parts requiring critical selection.

DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT STREET DETROIT 16, MICHIGAN

Circle 511 on Page 19



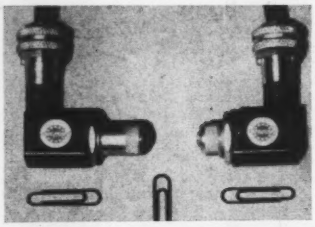
gain permit direct use with a variety of piezoelectric transducers without fall-off at low frequencies. Units operate with recommended minimum load of 10,000 ohms. **Gulton Industries Inc.**, 212 Durham Ave., Metuchen, N. J. D

Circle 683 on Page 19

Miniature Photoheads

have light-source life of 5000 hr

New miniature photoheads, designed to solve the problem of mounting a sensing device in a limited area, are slightly longer than a standard paper clip. Average light-source life is 5000 hr, and units can also be used as reflected-beam photoheads. Designed for industrial use, photoheads can be furnished with alignment brackets to insure proper relation of light source and receiver. **Electronics Div., Post Machinery Co.**, 150 Elliot St., Beverly, Mass. B

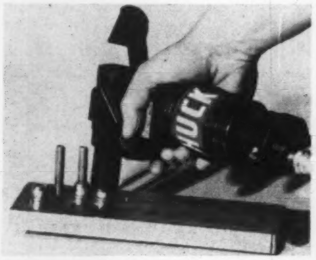


Circle 684 on Page 19

Fastener

has wide material thickness range

C6L utility Huckbolt fastener is recommended for joining wood, metal, rubber, plastic, honeycomb, and other materials which are difficult to fasten together. It incorporates basic features of standard Huckbolt fastener, but extends range of material thicknesses that can be joined with a given fastener size. Unit is available in 3/16, ¼, 5/16, ⅜, and ½-in. nominal pin diameters and in all head styles for metal-to-metal application. Available pin materials are 2024-T4 aluminum alloy, 6061-T6 aluminum alloy, C1022 mild steel, or AISI Type 321 stainless steel. Mild-steel pins are furnished plain, cadmium plated, or with zinc chromate or Unichrome surface treatment. Fastener is installed with Huck air or hydraulically driven power tools, or with hand tools where applicable. **Huck Mfg. Co.,** 2480 Bellevue Ave., Detroit 7, Mich. H



Circle 685 on Page 19

Solenoid Valve

for up to 200 psi pressures

New solenoid valve has full 1/8 and 3/16-in. orifices that permit operation in pressure range to approximately 200 psi. Valve is constructed with one-piece internal moving part, and has O-ring seals. Coil is completely sealed from air, oil, gas, and water, and will not overheat on continuous duty. Same coil is used for continuous or intermittent duty, ac or dc. Valve can be bottom drilled for manifolding, or tapped (shown) for standard connection, 1/8 or 1/4 NPT. **Airmatic Valve Inc.,** 7317 Associate Ave., Cleveland 9, Ohio. G

Circle 686 on Page 19

Rotary Air Motor

for limited-space operations requiring up to 1/8 hp

Keller 71A-1 rotary air motor de-

Small
Spring Loaded
Automotive
Spring Loaded
Heavy Duty
Spring Loaded
Oil or Dry
Multiple Disc
Heavy Duty
Over Center
Light
Over Center
Power
Take-Offs
Speed
Reducers
ROCKFORD CLUTCHES and POWER TAKE-OFFS
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ROCKFORD CLUTCH LEVERS

- Reduce friction and wear
Improve clutch release action
Prevent lever throw-out

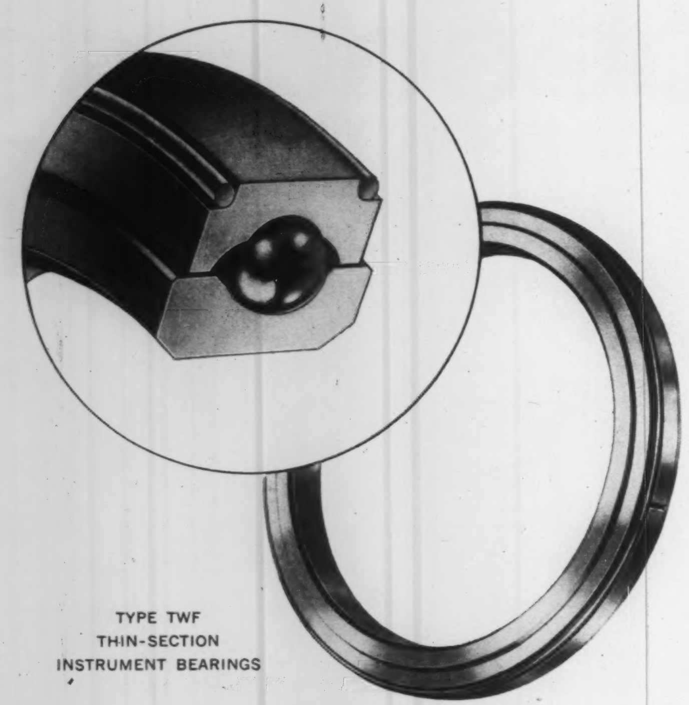
Patented rolling fulcrum pin action, in the release lever, results in much less friction and wear, and smoother release operation in this clutch than in some other types of clutches. Pin automatically returns to original position. Carefully balanced levers avoid lever throw-out at high speeds.

SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER
311 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

Circle 512 on Page 19


TYPE TWF
THIN-SECTION
INSTRUMENT BEARINGS

integral shielding plus these other advantages

1. No loading slot — continuous shoulders for maximum thrust as well as radial loads
2. Full ball complement — for highest radial and thrust load capacity — or
3. Alternate undersize balls for extremely low torque requirements
4. Two precision grades

Only SBB T Series thin-section instrument ball bearings offer these combined advantages — maximum load capacity, high precision, longer life, extra protection — all at competitive costs. T Series ball bearings are made in two high precision grades to AFBMA dimensions for B-500 Series. Available in 5 types and 12 sizes with bore sizes from 0.625″ to 3.0625″.

TWF
TWA
TCF
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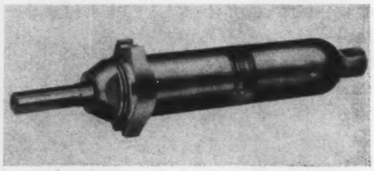
TCR

Write for new T Series Catalog 59
containing complete information.

split ballbearing
A DIVISION OF MPB, INC.
304 HIGHWAY FOUR, LEBANON, NEW HAMPSHIRE

Circle 513 on Page 19



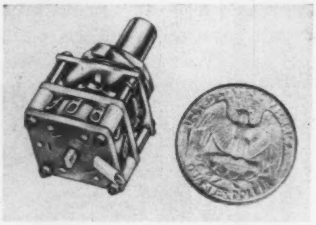
velops $\frac{1}{8}$ hp and up to 36 lb-in. stall torque. It is available in basic speeds of 20,000, 5000, or 1000 rpm. Adjustable plug-type regulating valve permits changing speed and torque in any of the three basic units. Motor and gearing are designed for lubrication with a fine mist of oil provided by an air-line lubricator. Muffling installed on front of spindle case keeps noise level to a minimum. Unit is designed for limited-space applications. **Gardner-Denver Co.**, Williamson & Front Streets, Quincy, Ill. I

Circle 687 on Page 19

Rotary Switch

has current-carrying capacity of 3 amp

New MA-12 miniature rotary switch provides 30-deg indexing, 12 contact positions, up to 5 sections, with current-carrying capacity of 3 amp. Interrupting rating is $\frac{1}{2}$ amp 115 v ac. Switch meets military specification MIL-S-3786. It can be furnished with up to six poles per section, and rotation can be unlimited or limited from 2 to 12 positions. Unit is $\frac{3}{4}$ in. square with maximum back-of-panel depth of $2\frac{3}{4}$ in. **R-F Electronics Inc.**, Div., Electro Switch Corp., Weymouth 88, Mass. B

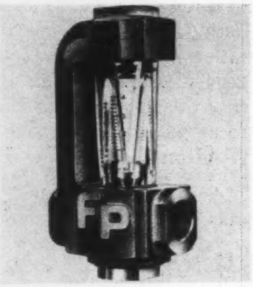


Circle 688 on Page 19

Flow-Rate Indicator

uses O-ring construction to seal metering tube

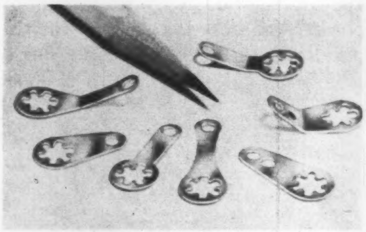
New Ratosight flow-rate indicator uses O-ring construction to seal metering tube, eliminating packing glands and stuffing boxes. Simple design makes cleaning and range changing easy. One-piece bronze body provides good strength-to-weight ratio. Unit is especially suitable for measuring flow rates of bearing lubricants and coolants, and is available with a vibrationproof alarm for high and/or low flows. Three meter sizes cover flow ranges from a fraction of a gallon per minute to 26 gpm of liquid, or 65 standard cu ft per min of gas. **Fischer & Porter Co.**, 797 Jacksonville Rd., Hatboro, Pa. E



Circle 689 on Page 19

Lock-Washer Terminals

of 0.018 brass or phosphor bronze



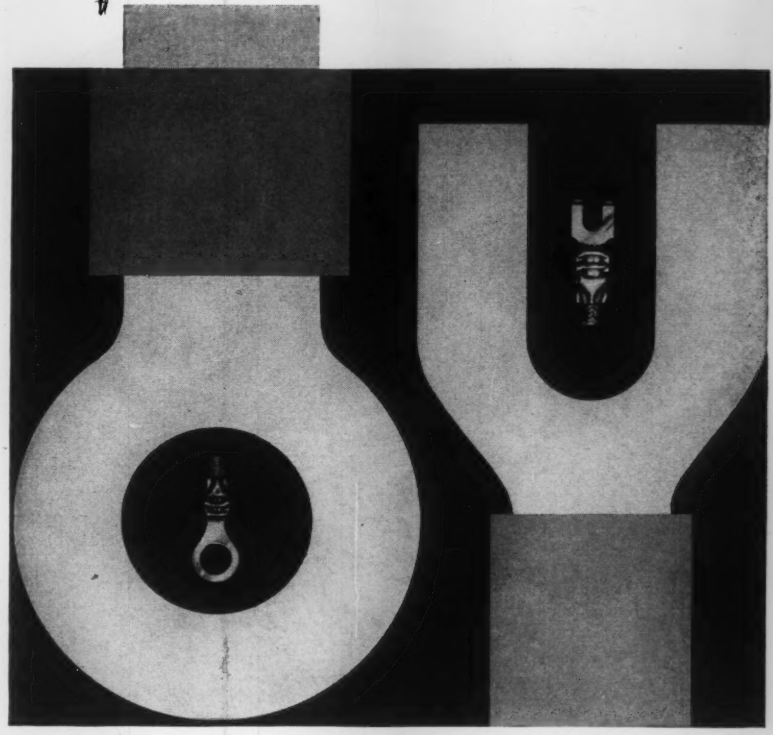
Seven new lock-washer terminals are designed to fit almost every need. They are available with No. 4, 6, and 8 holes, and are 0.018 brass or phosphor bronze, hot tinned. **Zierick Mfg. Corp.**, 110 Beechwood Ave., New Rochelle, N. Y. D

Circle 690 on Page 19

Coupling

has increased misalignment capacity

Anchor cut-out coupling provides overload protection, has increased misalignment capacity, and permits ease of maintenance. The torque-sensitive coupling shuts off power at the instant of a dangerous overload. Increased misalignment capacity



For perfect insulated termination . . .

faster . . . specify the A-MP®

PRE-INSULATED DIAMOND GRIP terminal

If you need terminals with bonded insulation—if you need corrosion resistance and wire-supporting vibration resistance—you have it instantly in one closure of A-MP's matched crimping tool. Only one lightning-quick step for crimp-sure optimum strength and conductivity. A-MP PRE-INSULATED DIAMOND GRIP Terminals exceed the most rigid military and commercial specifications.

A-MP's precision-engineered terminals are matched to precision-engineered tools that make an exact crimp every time, never too little, never too much. Perfect terminations—whether you need one or a million. No great operating skill necessary. A-MP's match-mated tooling does all the work and at lower installed cost than other methods of wire termination. Wire range is from No. 26 to No. 10.

To solve your wire-end problems, we maintain an international engineering service.

For the full story on the A-MP PRE-INSULATED DIAMOND GRIP line, send for our catalog.

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

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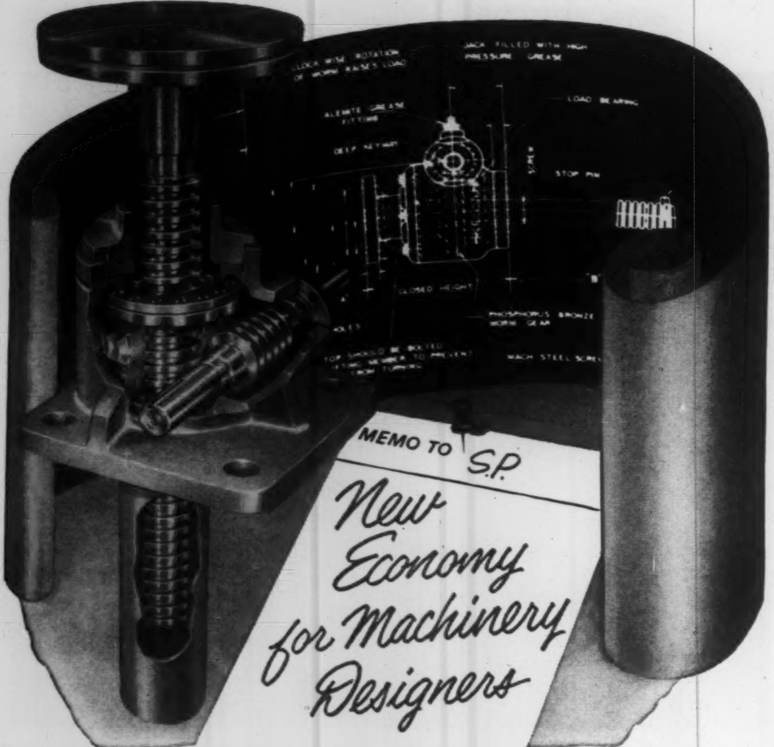
Circle 514 on Page 19


CLOCKWISE ROTATION OF WORM RAISES LOAD
JACK FILLED WITH HIGH PRESSURE GREASE
ALEMITE GREASE FITTING
LOAD BEARING
DEEP KEYWAY
SCREW
STOP PIN
CLOSED HEIGHT
PHOSPHORUS BRONZE WORM GEAR
HOLES
TOP SHOULD BE BOLTED TO LIFTING MEMBER TO PREVENT SCREW FROM TURNING
MACH STEEL SCREW
MEMO TO S.P.
New Economy for Machinery Designers

NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

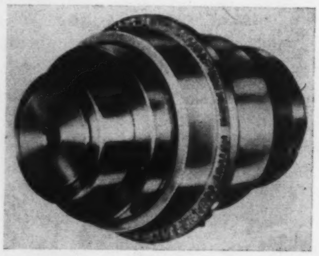
DUFF-NORTON COMPANY
P. O. Box 1889 • Pittsburgh 30, Pennsylvania
COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

D DUFF-NORTON N

COFFING HOISTS
Ratchet Lever
Hand Chain, Electric

Circle 515 on Page 19



provides for slight parallel misalignment, angular misalignment, or a combination of both. Coupling works regardless of direction of rotation. Only the sleeve of the coupling needs to be moved for maintenance. **John Waldron Corp.**, New Brunswick, N. J. D

Circle 691 on Page 19

Panel Meter

has antiparallax scale

Model MM-3 Medalist meter, a $3\frac{1}{2}$-in. unit, incorporates an antiparallax scale that places dial markings in the same plane as the pointer. Calibrated portion of scale is raised from dial face and is in same plane as pointer. Pointer tip swings under scale so that calibration marks, from any angle, appear to be a continuation of pointer, eliminating errors due to parallax. Unit is available in a variety of colors, standard types, and ranges. **Marion Electrical Instrument Co.**, Grenier Field, Route 28A, Manchester, N. H. B

20
40
60
80
100
120
140
volts
DIRECT CURRENT

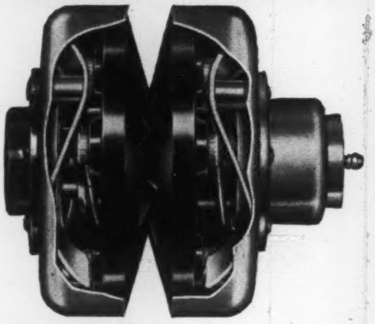
Circle 692 on Page 19

Pressure Control

differential-type unit is explosionproof

Type J99K explosionproof differential pressure control is used for air, gas, or liquid pressures where it is necessary to lower the difference between two separate pressures or vacuums. Control is uncalibrated, and pressure settings are made by

Hi-Lo Load-O-Matic Control Eliminates Pulley Slow Down



Hi-Lo Variable Speed Pulleys positively maintain the desired speed ratio over a wide range of load variation by means of an exclusive cam and cam follower assembly. This means:

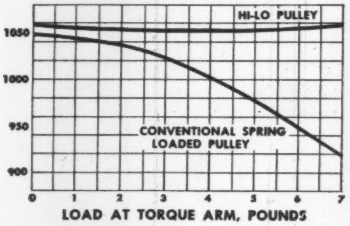
Pulley speed is independent of load and load changes. "Drag" is eliminated and high shock absorbency provided.

Pulleys do not compress belt due to spring pressure. Springs are not driving members. They act only to keep pulley faces in contact with belt.

Pulleys automatically regulate belt tension. Because of the cam assembly, belt is never under more tension than required by the load.

Double cams maintain constant belt alignment.

HI-LO PULLEYS COMPARED TO OTHER VARIABLE SPEED PULLEYS



PLUS THESE OTHER FEATURES:

- Smaller in size than comparable units.
- Quickly and easily installed.
- Replaceable face assemblies drastically cut repair and replacement costs.
- Available in sizes from .5 to 5 hp., ratios to 2.5/1 (single pulley) 6.25/1 (double pulley).

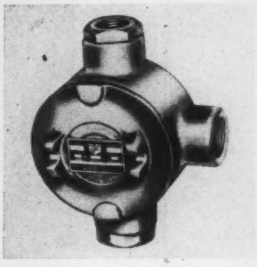
Request details and prices. Ask for Bulletin A-458.

Manufactured By
HI-LO
MANUFACTURING
COMPANY

Nationally Distributed By
LOVEJOY FLEXIBLE
COUPLING COMPANY
4968-H W. Lake St.
Chicago 44, Ill.

Circle 516 on Page 19

removing cover and setting hex-head adjustment screw. Snap-action switch is actuated when pressure on high side exceeds pressure on low side by preset amount, regardless of static pressure values. Switches available include normally open, normally closed, or double throw with no neutral position. They are rated for 15 and 20 amp at 115/230 v ac. All switches are single pole and suitable for ambient temperatures to 180 F. **United Electric Controls Co.**, 79 School St., Watertown, Mass. B

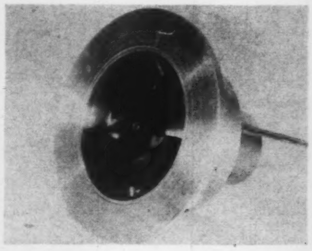


Circle 693 on Page 19

Miniature Blower

delivers about 45 cfm free air

New 20-v dc vane-axial blower with nominal motor speed of 13,000 rpm delivers approximately 45 cfm free air. Unit operates in ambient temperatures of −55 to 85 C for 500 hr without brush change. Housing diameter is 2.16 in. with overall length of 2.125 in.; flange diameter is 3 in. Unit meets MIL-M-8609. **Western Gear Corp.**, P. O. Box 182, Lynwood, Calif. L



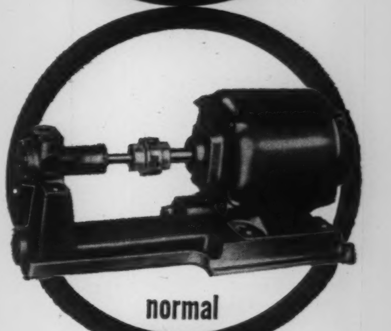
Circle 694 on Page 19

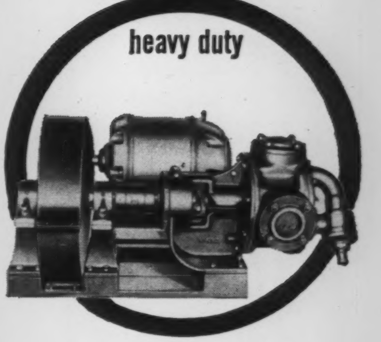
Air Filter

is fully automatic

New air filter thoroughly removes harmful moisture, rust, pipe scale, and other contaminants from air lines to prevent damage and exces-

What job
do you have
for a
**VIKING
PUMP?**





Sizes From 2/3 to 1050 G.P.M. Capacities

There is a Viking positive displacement pump for most industrial pumping requirements . . . probably yours. If you need fast, self-priming along with positive, smooth delivery, Viking Pumps are your answer — whether liquids are thin or thick.

In the Viking Pump line there are 750 cataloged models in 20 sizes, with additional thousands of specially built pumps available. This wide selection assures you of the right pump to fit your needs.

So, install Viking Pumps! Save space; Save dollars! Save installation and operating time! And let one of the simple Viking "gear-within-a-gear" pumps do your job the way you want it done.

Send today for Catalogs Section BH and CH

**VIKING
PUMP COMPANY**

Cedar Falls, Iowa, U.S.A.
In Canada, it's "ROTO-KING" Pumps

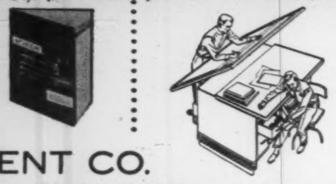
See Our Catalog in Sweets Product Design File

Circle 517 on Page 19

NEW STACOR-MATIC
WITH TOE TOUCH CONTROL
the drafting table that makes engineering sense

- Increases productivity, efficiency
- Saves man-hour costs
- Reduces waste motion
- A complete work-station in one unit.

Get all the facts—send for illustrated Bulletin 603 and complete NEW Stacor catalog



STACOR EQUIPMENT CO.
273 Emmet St., Newark 5, N. J. • Bigelow 2-6600

Circle 518 on Page 19

Announcing a
MAJOR BREAK-THROUGH by MAGTROL in SUB-MINIATURE MAGNETIC CLUTCHES AND BRAKES!

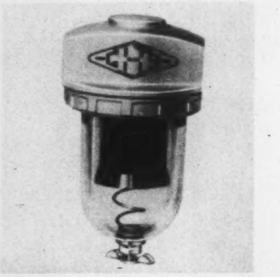
MAGTROL
BUFFALO, N
LIBERTY
1957

- More than doubles previous Torque output. Torque now guaranteed 8 oz. in. minimum.
- Control wattage decreased more than 50%. Now less than 1 watt.
- Response time decreased over 70%.
- Making MAGTROL Clutches the fastest known electromagnetic clutches and brakes commercially available.

Write for **DATA BOOK FCX-59**

MAGTROL, INC.
252 SENECA ST. BUFFALO 4, N. Y.

Circle 519 on Page 19



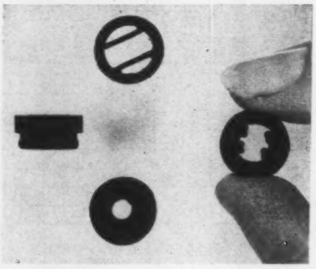
sive wear to pneumatic equipment. Large petcock at bottom permits fast, complete removal of materials. Simple construction makes the unit easy to disassemble for cleaning. **Pneumatics Div., Gits Bros. Mfg. Co.**, 1866 S. Kilbourn Ave., Chicago 23, Ill. I

Circle 695 on Page 19

Transistor Mounting

for all sizes and shapes of transistors

New transistor mounting with 7/16-in. diam hole provides a standardized mounting for all transistors regardless of size or shape. It offers excellent shock resistance and prevents movement of transistor when subjected to severe vibration. Long transistor leads provide good heat sinking. Temperature range is from − 60 to 99 C, with hot continuous-operating temperature of 85 C. Outstanding electrical properties include low dissipation factor, low conductivity, low dielectric constant, and high surface and volume resistivity. **Delbert Blinn Co.**, P. O. Box 757, Pomona, Calif. L



Circle 696 on Page 19

Magnetic Amplifier

drives electrohydraulic servo valves

Model 405 amplifier drives electrohydraulic servo valves in missiles, aircraft, and industrial control systems. It has response characteristics to 50 cps, permitting use in critical response systems. Unit is hermetically sealed in a self-contained, plug-in package. External gain and balance controls are not required, as amplifier is inherently stable. Unit requires less than 3.0 w of 115-v, 400-cycle power, and weighs less than 9.5 oz. It withstands temperatures to 125 C and shock to 100 g. **Acromag Inc.**, 22519 Telegraph Rd., Detroit 41, Mich. H

Circle 697 on Page 19

Tubing Assemblies

prefabricated units maintain their shape

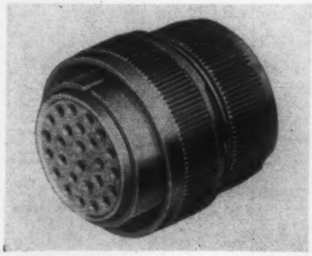
Prefabricated tubing assemblies are available in ODs of 1/8, 3/16, 1/4, 5/16, and 3/8 in., and in short-time burst-pressure ratings of 1000 and 2500 psi. Tubing is cut, flared, prebent, and equipped with nylon or metallic fittings. Assemblies are light in weight and have excellent storage life. They are form stable and maintain their shape. **Polymer Corp. of Pennsylvania**, 2140 Fairmont Ave., Reading, Pa. C

Circle 698 on Page 19

Connectors

for use at extreme altitudes

EX connectors are resistant to heat and vibration, and are sealed for use at extreme altitudes. They meet all requirements of MIL-C-5015 and MIL-E-5272. Connectors can be



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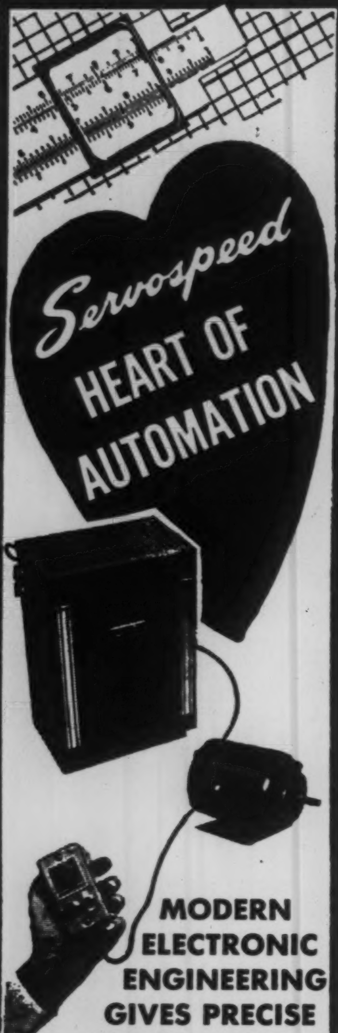


MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARmory 4-8989

Circle 521 on Page 19

operated continuously at temperatures to 325 F, and maintain sealing characteristics necessary to prevent voltage flashover at high altitudes. **Cannon Electric Co.,** 3208 Humboldt St., Los Angeles 31, Calif. L

Circle 699 on Page 19

Pillow Block

has wide inner-ring ball bearing

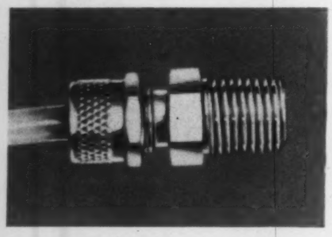
New standard series LAKH pillow-block ball bearing meets requirements for varying over-all dimensions. It has a wide inner-ring ball bearing which incorporates a frictionless and wearless mechanical seal which keeps lubricants in and foreign matter out. Unit is self-aligning in any direction. **Fafnir Bearing Co.,** New Britain, Conn. B

Circle 700 on Page 19

Knurled Nuts

for connections on glass and plastic tubing

New knurled nuts, available in 1/16 to 1 in. tube OD sizes, are designed for connections on glass and plastic tubing. Nuts are particularly recommended for installations which are hard to reach. When nut is finger-tight, fitting forms a leakproof seal. Wrench pad permits use of wrench if desired. **Crawford Fitting Co.,** 884 E. 140th St., Cleveland 10, Ohio. G



Circle 701 on Page 19

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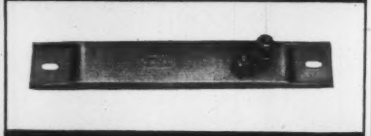

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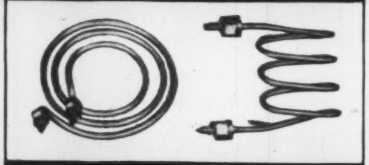

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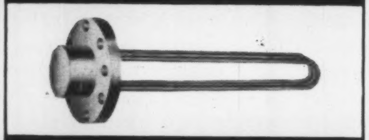

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Circle 522 on Page 19

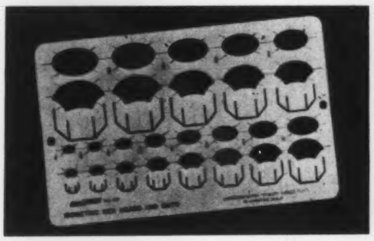
ENGINEERING DEPARTMENT

EQUIPMENT

Isometric Template

facilitates drawing of hex heads and nuts

No. 122 template facilitates the isometric drawing of hexagon bolt heads and nuts. Cutouts have range of 13 sizes from $\frac{1}{4}$ to 1 in. as measured along isometric axes, in increments of 1/16 in. Each size has three cutouts—an ellipse for the chamfer circle, a cutout for chamfer arcs, and one for corners of hexagon. Lower part of the latter can be used to draw an isometric hexagon without chamfer. By using second cutout upside down, a nut with chamfer on both sides can be depicted. Template measures $8\frac{3}{4}$ x $5\frac{1}{8}$ in., and is 0.030-in. mathematical-quality plastic. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L



Circle 702 on Page 19

Breadboards and Hangers

are aluminum with chromic acid anodize

Improved breadboards are available in 8 x 8, 8 x 16, and 16 x 16-in. sizes. Boards are jig bored with $\frac{3}{16}$-in. holes spaced on 0.250-in. centers. High precision in breadboard mockup is obtained by use of component and bearing hangers which can be shifted to any position or facing on the board. Tolerances in bearing hanger shaft hole are held to ±0.0000 and 0.0002 in. maximum. Hangers are offered holed for standard size components or blank for custom boring. Both hangers and breadboards are machined alumi-

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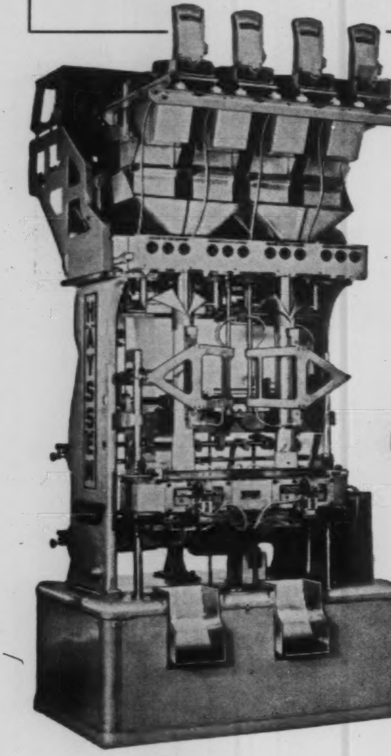
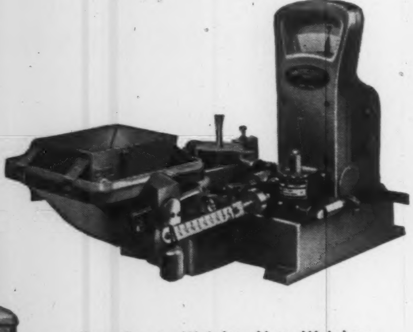
Circle 523 on Page 19

EXACT WEIGHT® SCALES control accuracy in Hayssen Packaging Machine



- Scale indicators provide a constant, visual check on each scale's accuracy while complete unit is in operation.
- Precision, even lever (1:1 ratio) scales assure minimum maintenance of weighing mechanism.



The Exact Weight Net Weigher, above, is available as original equipment for installation in any high speed filling and processing machines.

Four Exact Weight Scales, incorporated as original equipment in the Hayssen Model "F" Compak Automatic Packaging Machine, control each filling operation with extreme accuracy.

Product is fed into a weigh bucket mounted on the scale lever. When the scale balance moves within approximately $\frac{1}{2}$ ounce of specified weight, the fast feed is cut off and the trickle feed continues until it is shut off automatically at correct weight.

Exact Weight equipment can be incorporated into any machine that requires accurate control as a part of its operation. Complete engineering data is available. Write and give us your specific application.

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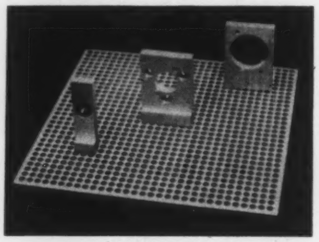
Circle 524 on Page 19



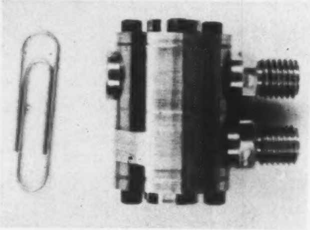
num and finished with chromic acid anodize. **Dynamic Gear Co. Inc.,** 20 Merrick Rd., Amityville, N. Y. D

Circle 703 on Page 19

Pressure Transducer

has flat diaphragm as presence-sensing element

Model P-501 adjustable-range pressure transducer is a double-coil, variable-reluctance type, and has a flat diaphragm as pressure-sensing element. It is for use in missiles, blast studies, industrial instrumentation, and other applications which require an instrument of small size with high response rates and resistance to serve environmental conditions. Unit translates gas or liquid pressure to proportional electrical signals used in recording or control systems. Output is 0.3 v per v over carrier frequency range from 400 cps to 70 kc, allowing operation of all standard telemetering channels. Instrument is $\frac{7}{8}$ in. in diam and $1\frac{3}{8}$ in. long; it weighs less than $2\frac{1}{2}$ oz. **Research & Development Center, Yuba Consolidated Industries Inc.,** Benicia, Calif. M

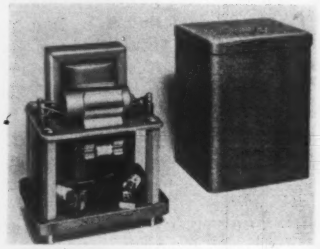


Circle 704 on Page 19

Miniature Power Supplies

are transistorized, ac-dc units

Transistorized ac-dc power supplies, each unit the size of a transformer alone, are for transistor, plate, and filament voltage. They are useful wherever dc power is required from an ac source, such as in the laboratory, and in the field for computers, telemetering and airborne electronic equipment, and missile circuitry. Units are available with or without regulation, and standard supplies operate from 105-125-v ac 60 cps, or 400-cps single-phase, or 400-cps three-phase input. Outputs range from 5 v dc to 28 v dc in power ratings to 5 amp, and from 100 v dc to 300 v dc in power ratings to 400 ma. **Universal Transistor Products Corp.**, 17 Brooklyn Ave., Westbury, L. I., N. Y. D

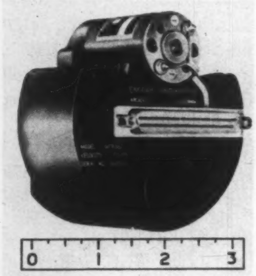


Circle 705 on Page 19

Tape Recorder

miniature unit has up to 13 channels

New tape recorder simultaneously records data from tests conducted under sever environmental and limited space conditions. Permanent record is obtained which can be analyzed later. Tape survives high impacts at termination of tests without loss of record. Recorder, which has up to 13 channels, features an in-line recording head, precision ball bearings supporting all revolving parts, adjustable motor speed and tape tension, and molded-rubber pressure roller and drive wheels. Recording time is 120 sec at 7½ ips. Weight of the unit is 22 oz. **Engdahl Enterprises**, Arcadia, Calif. L



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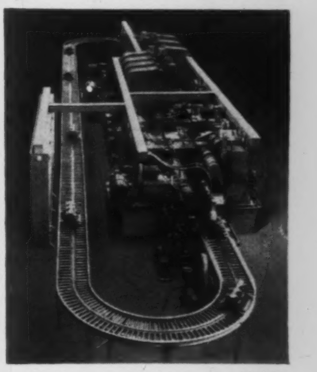
STEEL *from Wheelock, Lovejoy*
BULLETIN

W-L DETROIT For the first time, HY-TEN D-2 air hardening steel now available here in rounds, squares, flats and billets. Also a fine stock of standard alloy grades, especially A-8620, as well as all HY-TEN grades. Excellent service from our new warehouse.

W-L CHICAGO Steady demand for "B" No. 3X for flame-hardened parts such as boring bars. Good stocks of HY-TEN AIS—the best carburizing alloy steel, and freest machining available today—a new W-L exclusive!



W-L CINCINNATI This 23-station Avey Line-O-Dex transfer machine, designed and built by The Avey Division of Motch & Merryweather Machinery Co., Cincinnati, Ohio, is equipped with spindles made of our HY-TEN "B" No. 2. This grade was chosen for its great tensile strength (100,000 P. S. I. in the natural condition), toughness, and fine wearing qualities.

W-L CAMBRIDGE We are now distributing FLEXANGLE, the easy-to-erect structure assembly for all types of racks, shelves, platforms, etc. It's completely universal and low in cost—can be used anywhere, by anyone, for any storage purpose.

W-L HILLSIDE Our stock of flat and square sizes in HY-TEN M Temper Oil Hardening Steel can save you time and money in your tooling program. HY-TEN "B" No. 3X pre-heat treated in rounds, squares and flats available in a wide range of sizes. Billets on hand for hammer forging in all grades of HY-TEN.

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Circle 525 on Page 19

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS,** *President*
New Hampshire Ball Bearings, Inc.

CONTACT ANGLE

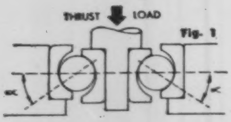

Fig. 1

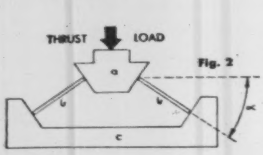

Fig. 2

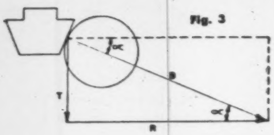

Fig. 3

Contact angle is the angle between a plane perpendicular to the bearing axis and a line connecting the two points on a given ball where the ball makes contact with the raceways when the bearing is subjected to a pure thrust load. In *Fig. 1*, the contact angle is represented by angle α. The significance of the contact angle is revealed by an examination of the forces present in a thrust loaded bearing.

In *Fig. 2*, a simplified version of *Fig. 1*, the shaft and inner ring combination are represented by the plug *a*, the "working diameters" of the balls and represented by the rodlike members at *b*, and the outer ring is represented by the tapered cup *c*.

The contact angle is α. This diagram represents a three-dimensional structure with as many equally spaced rods, *b*, as there are balls in the bearing.

The primary concern in design is the amount of compressive force to which rod *b* is subject, which is the force with which a given ball is pressed against the raceways. This force can be calculated by constructing a parallelogram of forces as shown in *Fig. 3*.

The sides T and R, are vector quantities, and diagonal B is the vector sum of T and R. Furthermore, the vector sum of the thrust components on all the balls equals the total thrust load on the bearing. The vector sum of the radial components on all the balls is zero. Vector B, the force actually felt by the raceways and balls, compared to vector T, the thrust component, varies significantly with changes in the size of the contact angle and is directly proportional to the thrust load component and inversely proportional to the sine of the contact angle.

Example I:

A bearing is carrying a pure thrust load of 21 pounds. Assuming seven balls in the bearing, each ball will have an axial load component of three pounds, since a thrust load is shared equally by all the balls. While the axial component on each ball is only three pounds, the actual compressive force, or squeeze, felt by the ball and raceways is considerably greater than this value.

With a contact angle of five degrees:

$$B = \frac{T}{\sin \alpha} = \frac{3 \text{ lbs.}}{\sin 5^\circ} = 34.5 \text{ lbs.}$$

Thus we see that with a five-degree contact angle the actual load felt by each individual ball is actually considerably greater than the total 21 pound thrust load on the bearing.

Example II:

Using the thrust conditions in Example 1, the contact angle is increased to 20 degrees, by selecting a bearing with a larger value of radial play.

$$B = \frac{3 \text{ pounds}}{\sin 20^\circ} = 8.78 \text{ pounds}$$

A 15 degree increase in contact angle produced a 74.5% reduction in ball-to-raceway contact stress. This relationship should be noted by anyone who writes bearing specifications. The operational qualities of the bearing, such as low running and starting torque and bearing life, are a function of the ball-to-raceway contact stress. Thus the contact angle is highly significant.

It is not necessary for a bearing user to calculate or specify the contact angle desired. It is only necessary to remember that low values of contact angle are associated with low radial play, and high values of contact angle are associated with high radial play. In addition to the above considerations, gyratory forces become extremely important factors in determining optimum contact angle in high speed applications.

A more complete discussion of contact angle is found in our design handbook.

DESIGNERS HANDBOOK OFFERED *FREE* TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

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Circle 526 on Page 19

THE ENGINEER'S Library

Recent Books

Engineering Vibrations. *By Lydik S. Jacobsen, professor and chairman, Department of Mechanical Engineering, Stanford University, and Robert S. Ayre, professor and chairman, Department of Civil Engineering, Johns Hopkins University;* 564 *pages,* 6 *by* 9 *in., clothbound; published by McGraw-Hill Book Co. Inc.,* 330 *West* 42nd *St., New York* 36, *N. Y.; available from* MACHINE DESIGN, $10.00 *per copy postpaid.*

This analysis of technical vibrations of linear and nonlinear systems emphasizes the transient state motion and considers the steady state as a special case. However, many important technical cases of steady-state vibrations are included. Classical methods of analysis are used where feasible, and extensive use is made of approximate methods.

Technical Editing. *By B. H. Weil;* 278 *pages,* 5 *by* 7½ *in., clothbound; published by Reinhold Publishing Corp.,* 430 *Park Ave., New York* 22, *N. Y.; available from* MACHINE DESIGN, $5.75 *per copy postpaid.*

Basic concepts and principles of technical editing are presented in this book. Coverage of subjects includes editing of technical reports, papers, abstracts, journals, manuals, and graphic aids.

Administration of Salaries for Engineers and Scientists. *By John W. Riegel;* 105 *pages,* 6 *by* 9 *in., paperbound.*

Intangible Rewards for Engineers and Scientists. *By John W. Riegel;* 84 *pages,* 6 *by* 9 *in., paperbound.*

Both books are published by and available from Publications Distribution Service, University of Michigan, Ann Arbor, Michigan. Each book $3.50 *per copy or both in one clothbound volume,* $6.00.

These reports are based on a study of utilization and motivation of engineers and scientists in industry. Included are many reasons for satisfaction and dissatisfaction with salaries or intangible rewards, and suggestions for improvement of these means for motivating engineers and scientists.

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This book presents principles and practices of industrial communication. Methods for handling technical information in such areas as technical writing, editing, illustrating, information services, patent collections, and research files are included.

Introductory Graphics. *By J. Norman Arnold, professor of Engineering Graphics, Purdue University; 543 pages, 7 by 10½ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN; *$7.75 per copy postpaid.*

This engineering drawing book emphasizes graphical solutions to engineering and mathematical problems. It is designed to aid in the graphic representation of objects, data, and physical phenomena, as well as the solution of space and graphical analog problems.

Insulation Engineering Fundamentals. *By Graham Lee Moses; 117 pages, 8 by 11 in., paperbound; published by and available from Lake Publishing Corp., 718 Western Ave., Lake Forest, Ill., $2.75 per copy.*

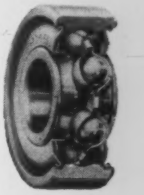
This book describes basic concepts, selection, application, construction, and testing of insulation for rotating machinery, and electronic equipment.

Association Publications

Automation Systems. 180 *pages, 6 by 9 in., clothbound; published by and available from Engineering Publishers, GPO Box 1151, New York 1, N. Y.; $5.00 per copy.*

Contained in this book are 16 papers on various aspects of automation presented at the Second Electronics Industries Association Conference on Automation Systems.

Don't Pay for Precision You Don't Need



RMB Filmoseal Bearings available in low-cost ABEC-1 as well as ABEC-5 tolerances.

Big news in the miniature bearing field! RMB's famous Filmoseal Bearings—the only sealed miniature bearings—are now made to low-cost ABEC-1 as well as ABEC-5 tolerances. This means designers can use these advanced design bearings even in those slightly less demanding applications where cost is a primary consideration. Designers can take advantage of such features as:

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Open radial Conrad-type bearings are also available in this new grade. A wide range of sizes is available from 3/16″ (0.1875″) to ½″ (.5000″) OD including many metric sizes.

Write for your copy of the new RMB Miniature Bearings Catalog which gives full details on these as well as the entire line of quality RMB Bearings. Ask for Bulletin 62.

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Circle 527 on Page 19

SPECON

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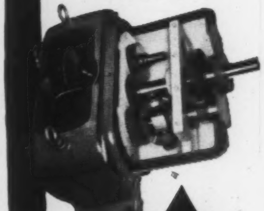
SPEED ACCURACIES TO .01%



Infinitely variable within a selected range, Specon Draw transmissions give accuracies approaching fixed gearing. By compressing the adjustment ratio into a narrow output range — 5% for example — speed accuracies within .01% are maintained regardless of load change.

One line in a family of Specon Drives & Transmissions manufactured by Stratos, these all mechanical, entirely positive transmissions provide speed control accuracies heretofore unavailable. Capacities to 20 horsepower and up.

Other Specon units include special differential gearboxes, wide range (zero to max.) adjustable speed mechanical and electrical differential drives with such unique characteristics as full torque at zero speed, shockless starts, smooth reversing.

For complete information, write to:

STRATOS Industrial Products Branch
#42, Route 109, West Babylon, N. Y.
Other Products: Turbo Expanders and Compressors, Pneumatic Pressure Regulators

Circle 528 on Page 19

NEW

AGASTAT
time / delay / relays
TYPE
2112-D-H1
COIL
28V DC
RANGE
.030-10 SEC.
SETTING
3 SEC.
SERIAL NO.
M 500
AGA

MINIATURE
AGASTAT®

time delay relay

for . . . missile, aircraft and electronic applications

INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds

UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC

ADJUSTABLE . . . time delays from .030 to 120 seconds

CHOICE OF OPERATION . . . for either energizing or de-energizing

SMALL . . . height—4⅝" . . . width—1-13/16" . . . depth—1½"

LIGHT . . . maximum weight—15 ounces

MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit, built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept. **A29-928.**

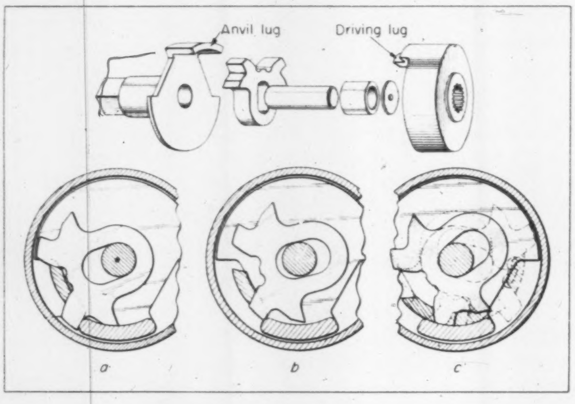
AGA DIVISION **ELASTIC STOP NUT CORPORATION OF AMERICA**
1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing

Circle 529 on Page 19

NOTEWORTHY
Patents

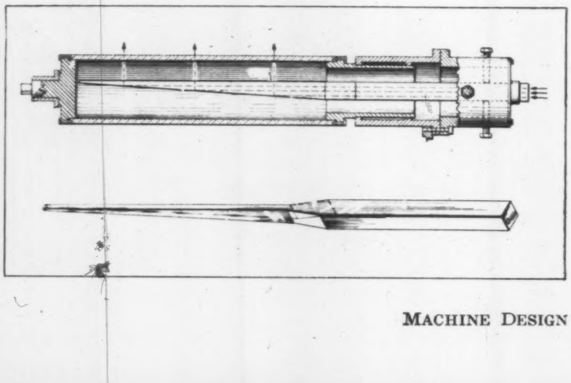
Reversible Torque-Limiting Mechanism

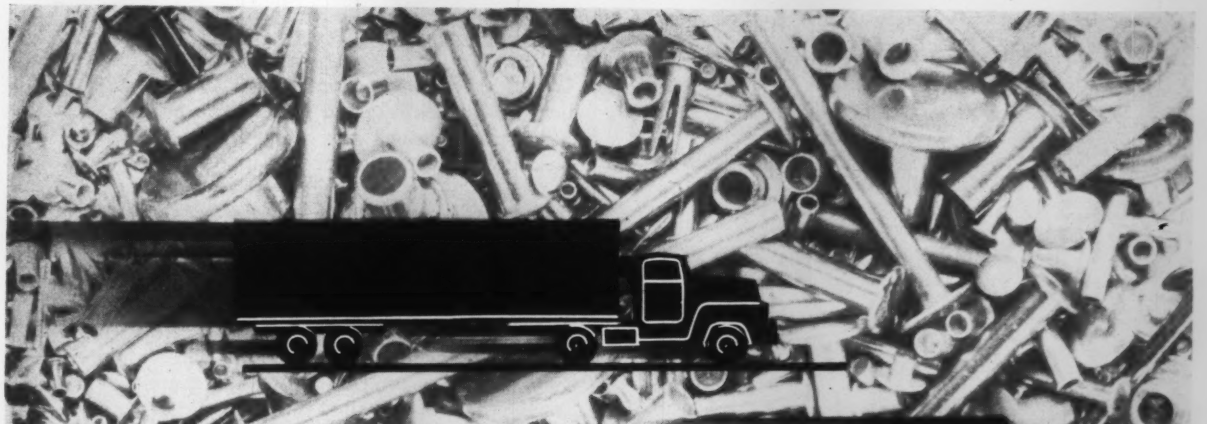
A drive assembly transmits fast rotation to a driven member until a limit of resisting torque is exceeded, then continues to release and engage with hammer-like blows as long as power is supplied. Key element is an impact cam mounted to float about a fixed pin and driven by a rotating lug. Below torque limit, centrifugal force holds the cam at its outermost position, *a*, engaging an anvil lug on the driven member. At the torque limit, the driving lug forces the cam over the anvil lug, *b*. Having passed the anvil, *c*, the cam returns to its outer position, travels freely for about 270 deg, and re-engages the driven lug with impact. Geometry of the cam shape determines limit torque. Direction of rotation and sequence of events are both reversible. *Patent 2,842,994 assigned to Aro Equipment Corp., Bryan, Ohio, by Robert E. Stine.*



Light Conductor

A slit of light, uniformly intense from end to end, is achieved with a long plastic prism one surface of which is accurately tapered and silvered. Parallel beams enter the end of the prism and reflect from the tapered sur-





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This new system keeps our inventory high so *you can keep yours low*. It's based on the 800 most-used standard rivets. It's backed up by productive capacity exceeding 20 million rivets a day. When your order comes in, semi-finished rivets are quickly finished to your specifications . . . and delivery is geared to *your production schedules*.

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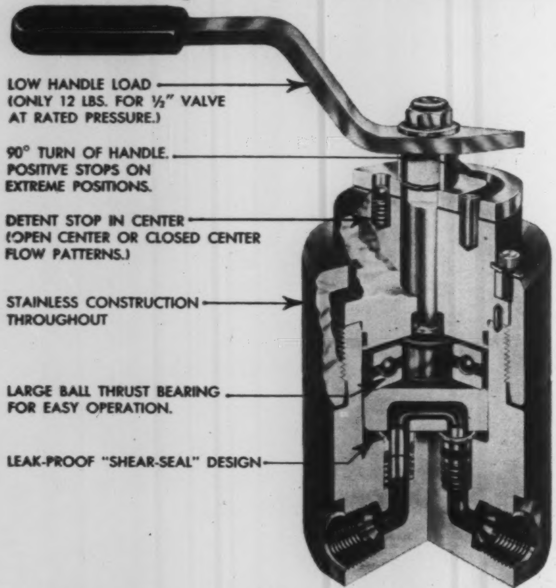
Circle 530 on Page 19

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

Write for Catalog 58-59

CONTROL VALVE DIVISION

barksdale valves

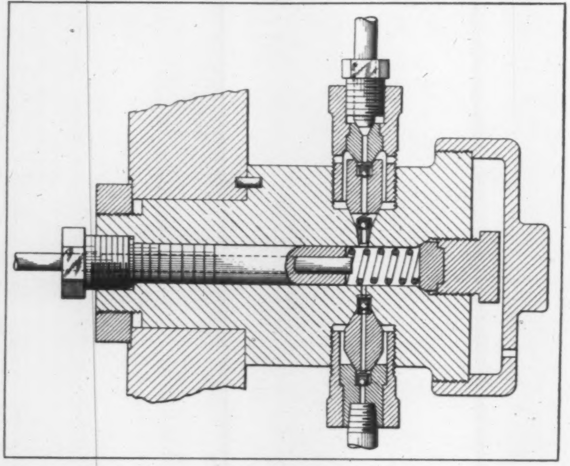
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

Circle 531 on Page 19

face. A converging section adjacent to the tapered length helps to concentrate the light. The prism material is transparent plastic, such as methyl methacrylate, with an index of refraction of 1.5 approx. Heat generated at the light source is not transmitted through the prism to the point of use. *Patent* 2,843,664 *assigned to Fairchild Camera and Instrument Corp., Syosset, L. I., N. Y., by Robert E. Olin.*

High-Pressure Pump

A reciprocating-plunger pump with tungsten ball valves in the suction and discharge channels can withstand pressures of 50,000 psi and can operate at a speed of 100 strokes per minute. Important features are the seals in the flow channels and at the cylinder end opposite the plunger. At all these points, sealing is accomplished by interference between adjacent conical surfaces having different slope angles—essentially circular line contact. Threads on these same members do not seal but only serve to load the contacting members. Seals around the reciprocating plunger are washers of metal, such as Babbitt or silver. *Patent* 2,841,092 *assigned to Milton Roy Co., Philadelphia, by Irvin R. Whiteman and John T. Barron.*

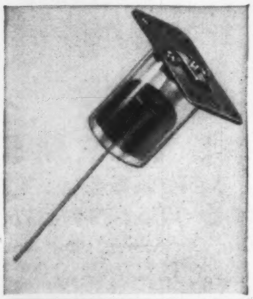


Adjustable Shock-Load Indicator

In a simple enclosure, intended for attachment to a larger article, a ball drops to indicate that a shock load has been exceeded. In its original position, the ball is suspended against the end of an adjusting screw between the poles of a magnet which forms the cap of the enclosure. The screw setting, which can be read from a graduated scale on the top of the enclosure, indicates the force holding the ball suspended. A shock force greater than the holding force drops the ball, and spring-loaded fingers prevent return to original position. *Patent* 2,843,076 *assigned to Aerophysics Development Corp., Santa Barbara, Calif., by Howard L. Cook, Leon R. Clark, Russell F. Knopp, and Dennis A. Marlow.*

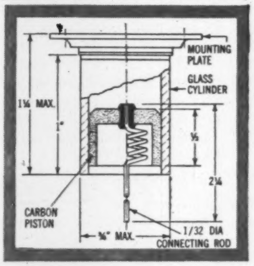
AIR DASHPOT

with Permanent Calibration



AIRPOT*

is the New Precision Dashpot, designed to meet your requirements for one-way or two-way ADJUSTABLE damping for time delay, vibration damping and stabilization. Precision bore glass tubing and carbon piston assure reliability through millions of cycles. Small in size, weighing less than an ounce, AIRPOT* units are easily mounted and adjusted.



PERFORMANCE DATA

Damping constant: adjustable up to 2.0 lbs/inch/sec.

Static and Sliding Friction Coefficient: less than 0.2

Temperature Range: from —75°C to 150°C.

Choice of cylinder lengths, and connecting rod spring gradients of 6.6, 10, 20 and 200 lbs.

Write or call for specific information

ELECTRIC REGULATOR CORPORATION / *Manufacturers of REGOHM* Regulators and MAGOHM* Magnetic Amplifiers* *T.M.
Norwalk, Connecticut • Victor 7-2401

Circle 532 on Page 19

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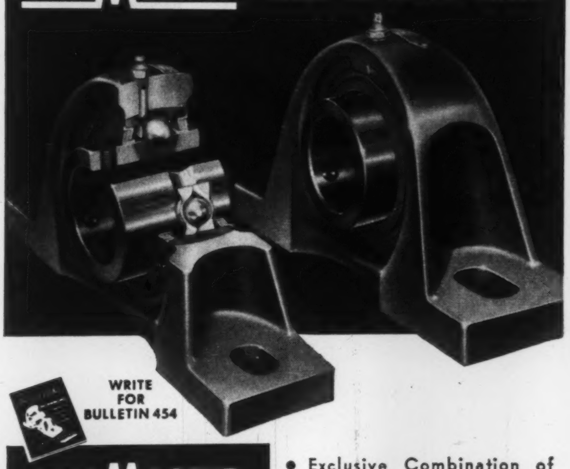

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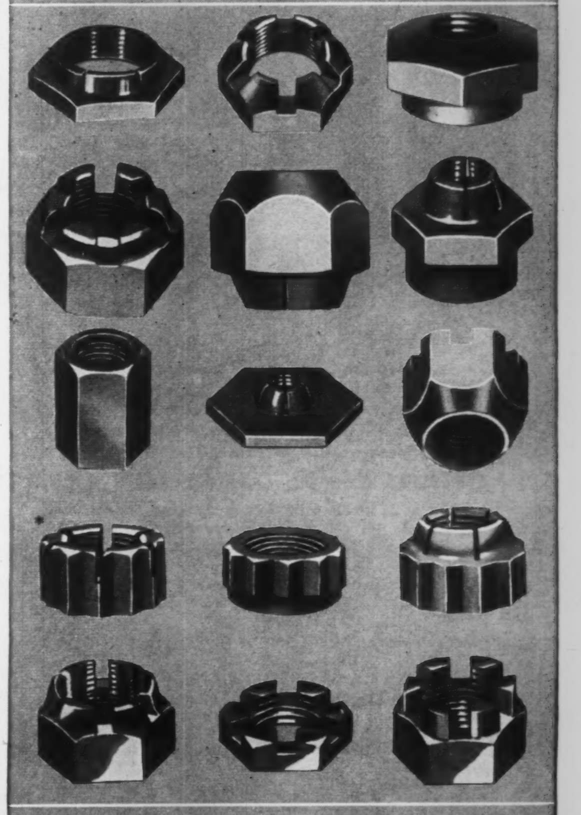
to specs. 7/16"—4¼" cross flats

special machines + large stock of material × years of experience = speedy deliveries high quality low prices



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*12 Pointer Standards, sizes: ¼" to ¾"—brochure on request

NATIONAL MACHINE PRODUCTS

*Manufacturer of Standard and Special *12 Pointer and Hexagon Nuts . . . "Huglock" and "Marsden" locknuts.*

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an SPS / COMPANY

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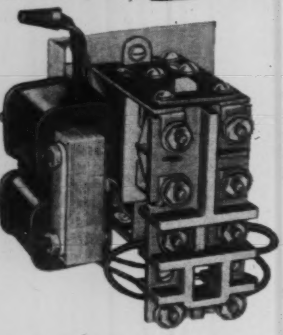
WARRICK Floatless Electrode Type

LIQUID LEVEL CONTROLS . . .

give you all these advantages!



No moving parts in the liquid • Easy to install • No adjustments necessary • Unaffected by acids or caustics • Unaffected by pressure or temperature • Standard 2&3 pole units listed by U/L

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YOU CAN USE OUR CONTROLS FOR:

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- Motor & solenoid valves
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SAVE DOLLARS
SOLVE PROBLEMS

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STAR'S STAINLESS HINGE FACT SHEET

A Star specialty!
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THERMOCOUPLE HEAD with

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use with 30 gage to 14 gage wire—maximum operating temperature of +300° F. (continuous) or +450° F. (intermittent). Ideal with Conax Thermocouple Glands, Conax Speedwells, Conax Flex-tube Assemblies, Conax Safetywells and other similar applications.

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conax corporation
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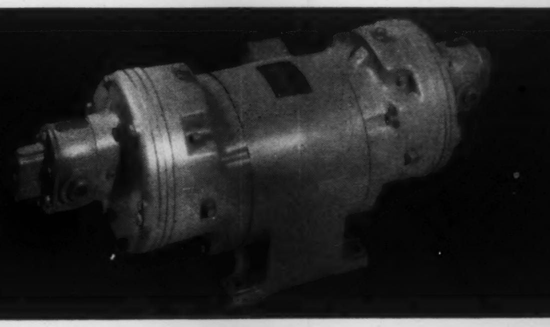
How stock pumps solve special problems



CASE HISTORY NO. F6989

This "100" Series Duplex Unit was developed from stock pumps and parts by Brown & Sharpe for a customer who needed a *compact* unit that would: (1) Deliver lubricating oil to a gear case, (2) Scavenge oil from the case and pump it back to the supply tank. These functions were accomplished by having two pumps driven through reduction gears from a single motor.

The 100 series incorporates a pump mounted on the end bell of an 1800 RPM gear head motor. Reduction gears are available to provide pump operation at speeds of 300 to 1000 RPM . . . to suit different volume requirements. Pump gears and shafts are one-piece case hardened steel; the housing, close-grained gray iron. Units are available with or without relief valves. Brown & Sharpe's complete line of gear, vane and centrifugal pumps, backed up by expert engineers, has saved money for customers in thousands of applications.

For information about B&S pumps for fluid transfer, please write to Brown & Sharpe Mfg. Co., Providence 1, R. I.

For information about pumps and valves for hydraulic applications, write to Double A Products Company (a subsidiary of Brown & Sharpe), Manchester, Mich.

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PUMPS • DOUBLE A HYDRAULIC VALVES • PRECISION TOOLS AND GAGES • MILLING, GRINDING AND SCREW MACHINES • CUTTERS • MACHINE TOOL ACCESSORIES

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LEPEL Electronic Tube GENERATORS—1 KW; 2½ KW, 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

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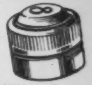
CLOSURES

- **Metal or Plastic Caps or Plugs to protect threads, tubes, machined parts, reamers, cutters, tools.**
- **Protect against thread damage, dust, dirt, and moisture.**
- **For inside and outside application. All sizes. Immediate delivery.**



METAL Caps to cover AN & SAE threads

PLASTIC tapered caps and plugs

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Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

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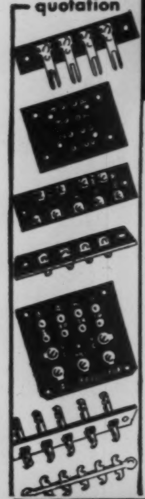

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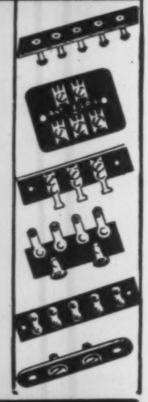

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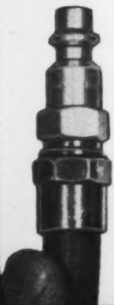
Quick Disconnects for Air—Fluids—Gases

These Series "D" Quick Couplings are interchangeable with all popular makes. They are ideal for fluid or gas applications up to 10,000 p.s.i. for Compressed air lines, Pneumatic tools, Industrial fluids, Instrumentation, Materials handling.



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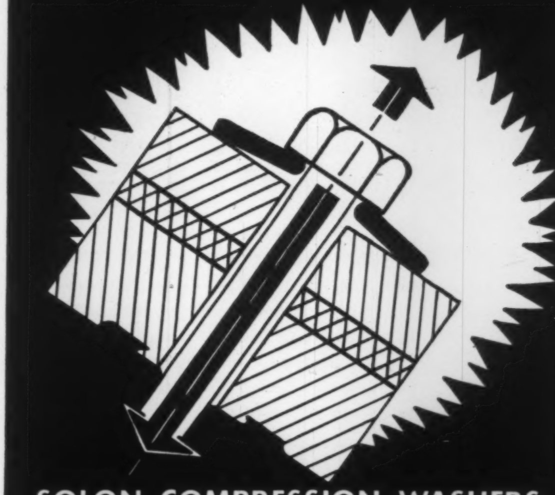
BOLT TENSION PROBLEMS?



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PRESTRESSED FOR MAXIMUM
LOAD IN MINIMUM SPACE

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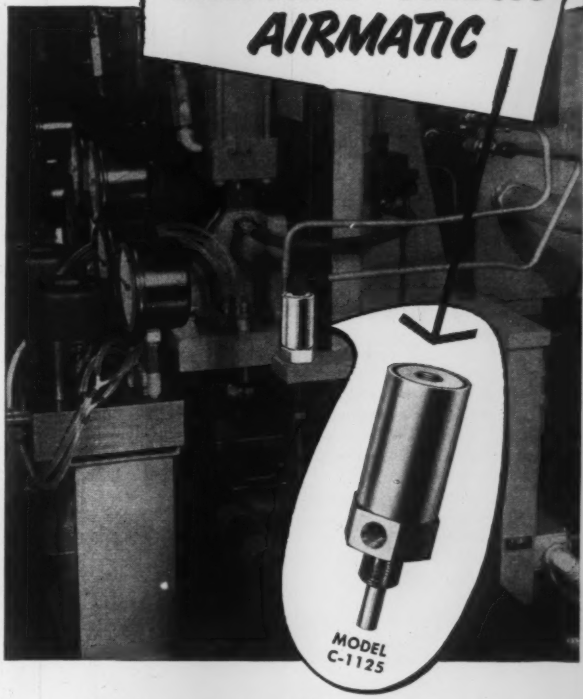

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PROBLEM: The Sheffield Corporation of Dayton, Ohio, wanted positive and reliable operation of the colormarking device used for identification of production items as produced by their connecting rod gaging machines.

SOLUTION: The Model C-1125 1⅛" small-bore cylinder shown above.

Airmatic cylinders are machined from brass tubing and bar stock. No castings are used. The front head is threaded to the cylinder tube. "O" rings of the aircraft type mean smooth trouble-free operation with long life between servicing of the packing. They are available in sizes of ⅜", ½", ¾", 1", 1⅛" and 1½" with single threaded end or clevis end.

OTHER APPLICATIONS: Airmatic small-bore cylinders are especially useful in test jigs, miniature air vises and in automatic work for feeding, ejecting, soldering, welding, brazing, stamping and bending as well as marking.

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AIRMATIC VALVE, INC.
7317 Associate Ave. • Cleveland 9, Ohio

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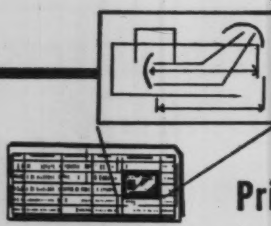

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Both cover the entire frame of a microfilmed engineering drawing. The Inspector "50"—a portable model—costs $59.50. The Inspector "25"—a vest pocket gadget—costs $5.50.

At these prices, everybody can have a reader.

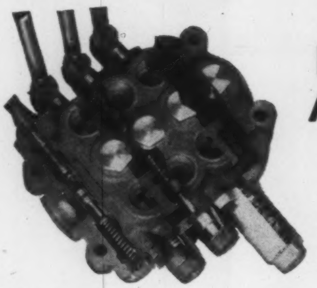
There isn't enough space in this advertisement for pictures and specifications. So, why not write us and ask for our new one-page brochure on the Inspector "50" and Inspector "25"?

The Filmsort Company
Pearl River, New York
A DIVISION OF MIEHLE-GOSS-DEXTER, INC..

Circle 549 on Page 19

Versatile!

New HUSCO "3200" Valve



Offers Power-Saving *Multi-Position* Control

Get the facts—and you'll recognize *unlimited* fluid control opportunities for this new HUSCO "3200" Multi-Plunger Control Valve. Here are some features:

- Choice of ONE to SIX plungers, with sealed ends—in completely balanced design.
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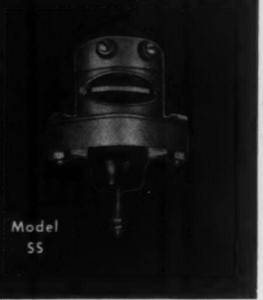

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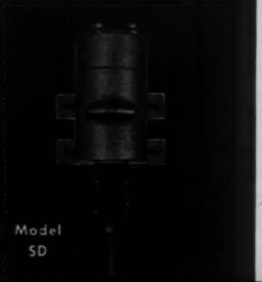

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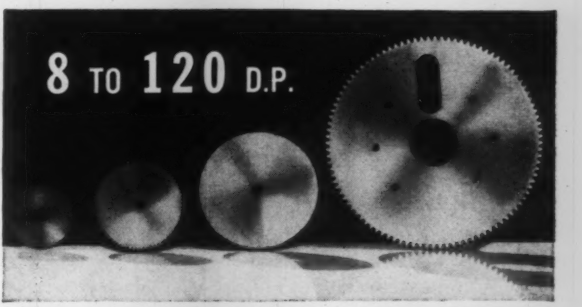

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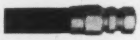

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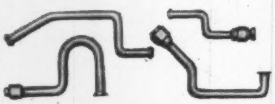

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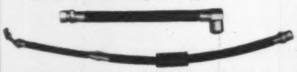

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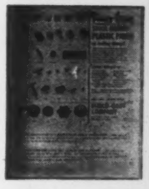

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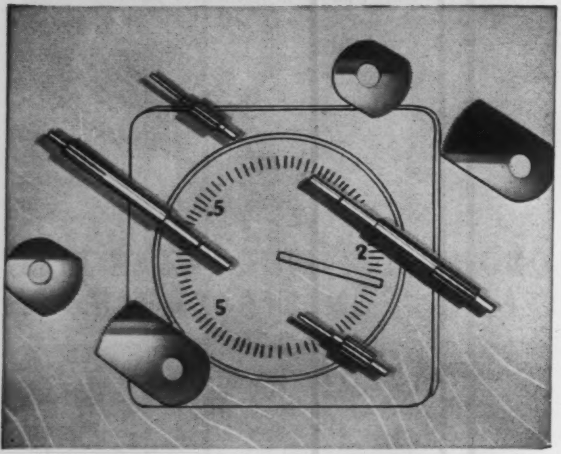

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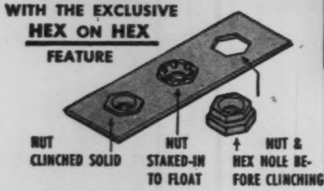

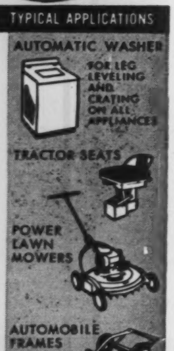

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MONDAY, OCTOBER 13

10 a.m.
SESSION 1—Fowler Hall—Memorial Center

EUROPEAN REPORT
Prof. J. Denavit, Northwestern University

SPACE MECHANISMS
Dr. Rudolf Beyer, professor of kinematics and mechanism design, Technical University, Munich, Germany

1:30 p.m.	**1:30 p.m.**	**1:30 p.m.**
SESSION 2A	**SESSION 2B**	**SESSION 2C**
Room 206	**Fowler Hall**	**Room 214**
Memorial Center	**Memorial Center**	**Memorial Center**

Session 2A
CYCLOIDAL CRANKS
E. H. Schmidt, senior mechanical consultant, E. I. du Pont de Nemours & Co.
INFLECTION CIRCLE AND POLODE CURVATURE
Prof. A. S. Hall Jr., Purdue University
APPLYING THE INFLECTION-CIRCLE CONCEPT
Prof. James C. Wolford and Prof. Donald C. Haack, University of Nebraska

Session 2B
DYNAMIC ANALYSIS OF CAM MECHANISMS
Prof. Ray C. Johnson, Yale University
CAM TORQUE CURVES
Prof. Harold A. Rothbart, City College of New York
PIVOTED-FOLLOWER CAM SYSTEMS
Robert L. Droke, associate engineer, International Business Machines Corp.

Session 2C
A MECHANICAL SQUARING DEVICE
Sigmund Rappaport, project supervisor, Ford Instrument Co.
MECHANICAL ANALOG COMPUTER COMPONENTS—1
George W. Michalec, section head, General Precision Laboratory Inc.

6:30 p.m.
BANQUET—Ballroom—Memorial Union Building
THE FUTURE OF AN ENGINEER
Dr. Richard W. Wallen, director, managerial training division, Personnel Research & Development Corp., Cleveland

TUESDAY, OCTOBER 14

8:30 a.m.	**8:30 a.m.**	**8:30 a.m.**
SESSION 3A	**SESSION 3B**	**SESSION 3C**
Room 206	**Fowler Hall**	**Room 214**
Memorial Center	**Memorial Center**	**Memorial Center**

Session 3A
FOUR-BAR FUNCTION GENERATORS
Prof. Ferdinand Freudenstein, Columbia University
POINT-POSITION-REDUCTION
C. Wesley Allen, engineer, General Electric Co.
THE FECUND FOUR-BAR
Prof. R. S. Hartenberg and Prof. J. Denavit, Northwestern University

Session 3B
CAM-DESIGN TABLES
C. N. Neklutin, vice president, Universal Match Corp.
DISC-CAM CURVATURE
J. Hirschhorn, school of mechanical engineering, New South Wales University of Technology, Sydney, Australia
HIGH-SPEED SPRING-ACTUATED CAMS
Philip Barkan, engineering research and development laboratory, Switchgear and Control Div., General Electric Co.

Session 3C
MECHANICAL ANALOG COMPUTER COMPONENTS—2
George W. Michalec, section head, General Precision Laboratory Inc.
NONCIRCULAR GEARS
Frederick W. Cunningham, president, Cunningham Industries Inc.

12:15 p.m.
LUNCHEON—Ballroom—Memorial Union Building

1:45 p.m.
SESSION 4—Fowler Hall—Memorial Center
MEASUREMENT AS A DESIGN TOOL
F. E. Fisher, manager, Electrical Analysis and Mechanical Analysis Lab., International Business Machines Corp.
MICROMOTION ANALYSIS VIA HIGH-SPEED MOVIES
William G. Hyzer, consulting research engineer, Janesville, Wis.
GENERAL DISCUSSION

Mail to: MECHANISMS CONFERENCE, Comptroller's Office (Conferences), Purdue University, Lafayette, Ind.

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If necessary, will share twin-bed room with another Conference member ☐
Twin Beds—Bath ☐
Room will be shared by ______

Please send confirmation:

Name ______
Company ______
Address ______

CONFERENCE REGISTRATION

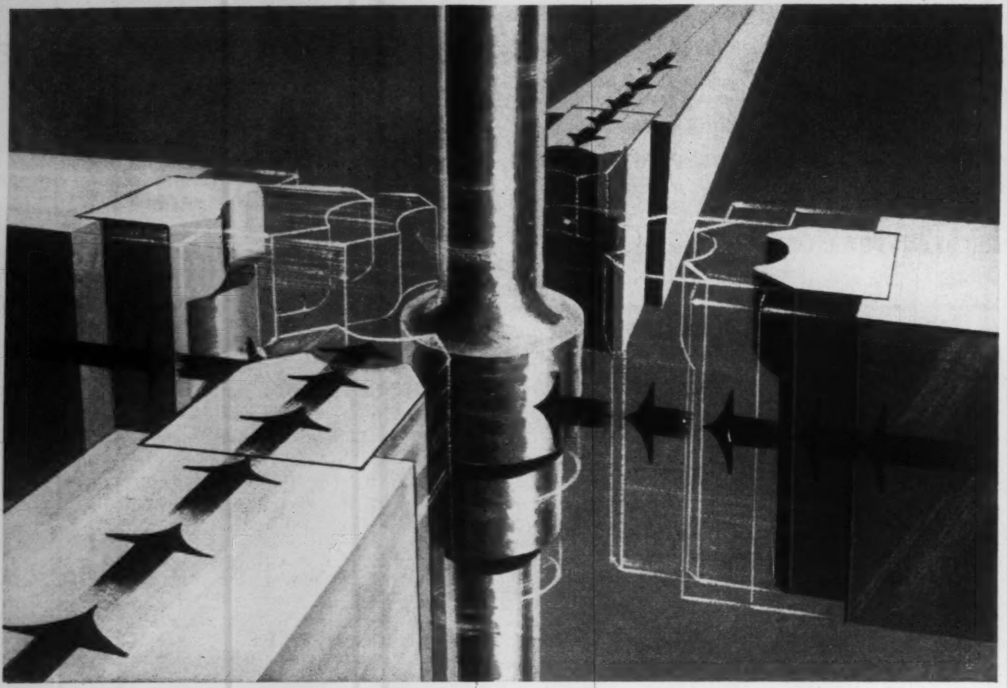
The following persons plan to attend the Mechanisms Conference, October 13 and 14, 1958 (name and title, please):

Fee enclosed
______ ☐
______ ☐
______ ☐

$______ is enclosed for the registrations checked at $35 each. (Make checks payable to Purdue University.)

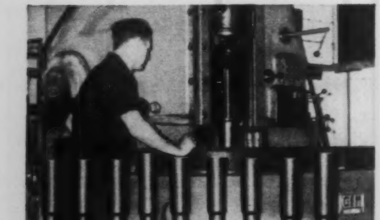
☐ Fees will be paid at registration time.

Name ______
Company ______
Address ______



ANOTHER **CURMET** PROCESS

New *Precision* ROTARY FORGE saves up to 30% on Finished Parts



Curtiss-Wright Exclusive Rotary Forge produces precision parts . . . saves industrial buyers from 15% to 30%.

Producing complex solid or hollow parts from *less metal* and with *greater accuracy*, the Curtiss-Wright Rotary Forge provides industry with a new, economical source for precision forgings.

Parts are hot-forged in this CURMET process to tolerances of .015 inches outside and .005 inches inside or to still higher tolerances when cold forged. Expensive finishing time is cut down, chip loss is minimized and added strength and toughness assured . . . with overall savings on the forged part of up to 30%.

The Rotary Forge, only one of its type in the United States, shapes parts by synchronized blows of four hammers, each striking up to 600 times a minute. Tapered steel truck axles, for example, are produced to accurate dimension in 25 seconds. Because dies are comparatively inexpensive, orders in moderate volume can be filled at lowered costs.

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FOR FULL INFORMATION, WRITE TO:

METALS PROCESSING DIVISION
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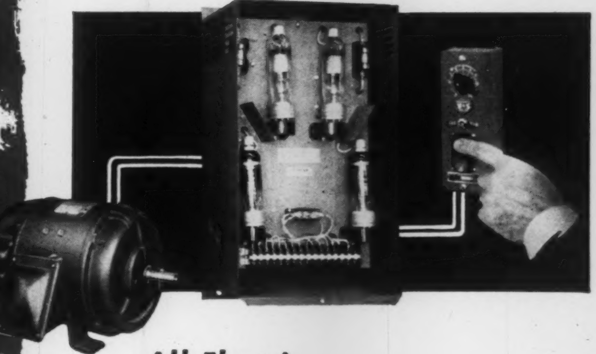
STOP
CHANGE DIRECTION
JOG
WIDE SPEED RANGE

New!

RELIANCE V★S Jr.



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The 8 to 1 motor speed ratio puts extra flexibility into your machinery. Speeds may be changed through this wide range as frequently as required. The motor will operate through a 100 to 1 speed range for jogging or light intermittent duty.

There's a big power cushion in the motor too . . . power for smooth speed pick up, even under heavy shock loads, and dynamic braking for fast controlled stops without shuddering or jerking.

The Reliance V★S Jr. is your answer to machinery drive problems in the ¾ to 4 horsepower range. Package construction makes installation easy; just plug it in to a single phase 220 or 440 volt a-c. line.

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